Town Hall Innovation Series

broadband forum
Town Hall Innovation Series

Artificial Intelligence and Machine Learning

Town Hall Innovation Series

Spring Member Meeting 2024

Artificial Intelligence and Machine Learning Town Hall – Agenda

1. Town Hall Introduction & Welcome
   Mauro Tilocca, TIM
2. Data and AI Architecture Strategy – Deutsche Telekom Perspective
   Mohammad Sharifan, Deutsche Telekom AG
3. AI based Cognitive Robotics: Changing the Way we Work
   Bernd Heinrich, Chief Growth Officer, NEURA Robotics
4. AI&ML for TIM network
   Roberta Giannantonio Head of Data Network Learning (AI for Operations), TIM
5. Harnessing Machine Learning for Enhanced Optical Networks: A State of the Art Update from IETF
   Adrian Farrel, Managing Director, Old Dog Consulting
6. AI/ML use cases for Access Network Management
   Benoît Drooghaag, AI/ML Application Expert, Nokia
7. AI Applications and Impacts on Broadband Network
   Aihua Guo, Principal Architect, Futurewei Technologies
8. EU funded AI@EDGE innovation project
   Jovanka Adzic, Technical & Project Leader, TIM

Data and AI Architecture

Challenges of a Large Enterprise Telco

Mohammad Sharifan
Lead Data and AI architect

Focus is creating business Impact

Business Impact

AI / ML Model

Focus is creating business Impact

Business Impact

AI / ML Model

AI Tool Stack / MLOps, Data Labeling, Data Categorization

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AI / ML Model

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Data Platforms / state of the art tooling, data pipelining,
Data Quality optimization

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Data Platforms / state of the art tooling, data pipelining, Data Quality optimization

Data Management Rules, Data Ownership and Data Quality at Process, Data Sharing

Focus is creating business Impact

Business Impact

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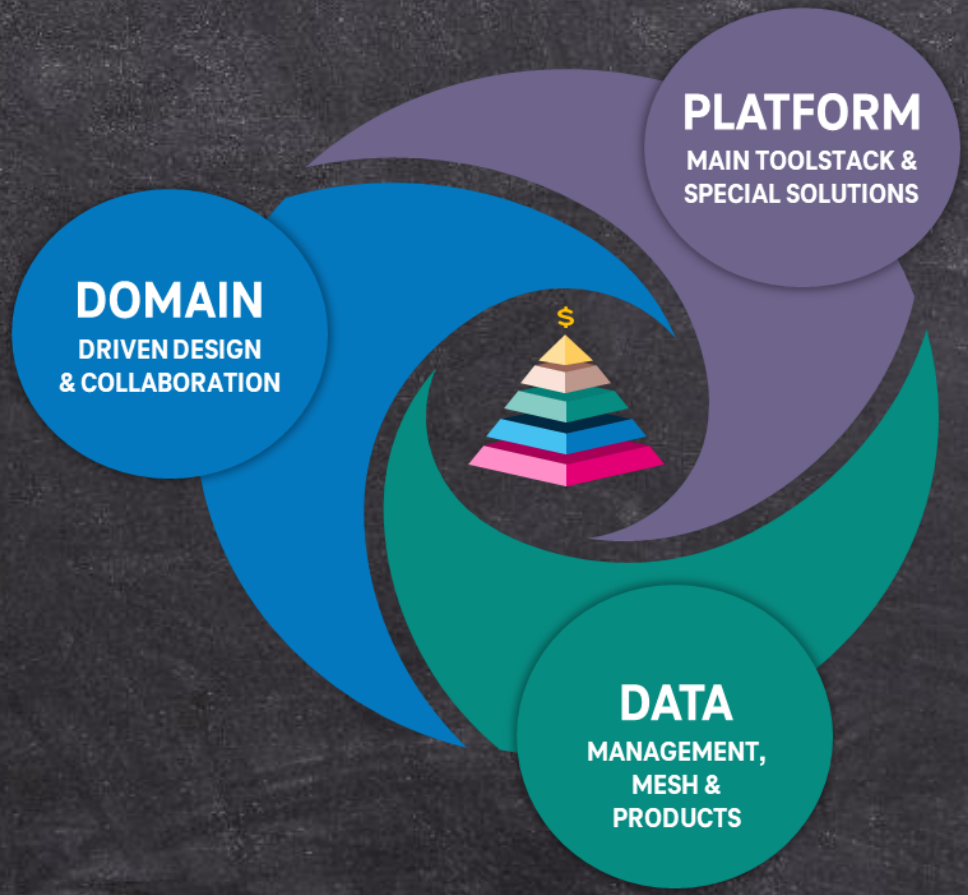
Data Platforms / state of the art tooling, data pipelining, Data Quality optimization

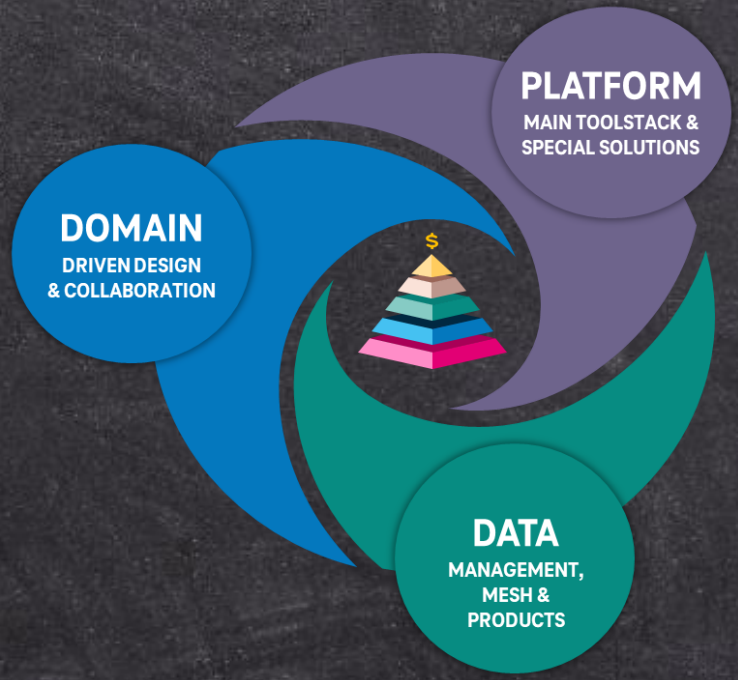
Data Management Rules, Data Ownership and Data Quality at Process, Data Sharing

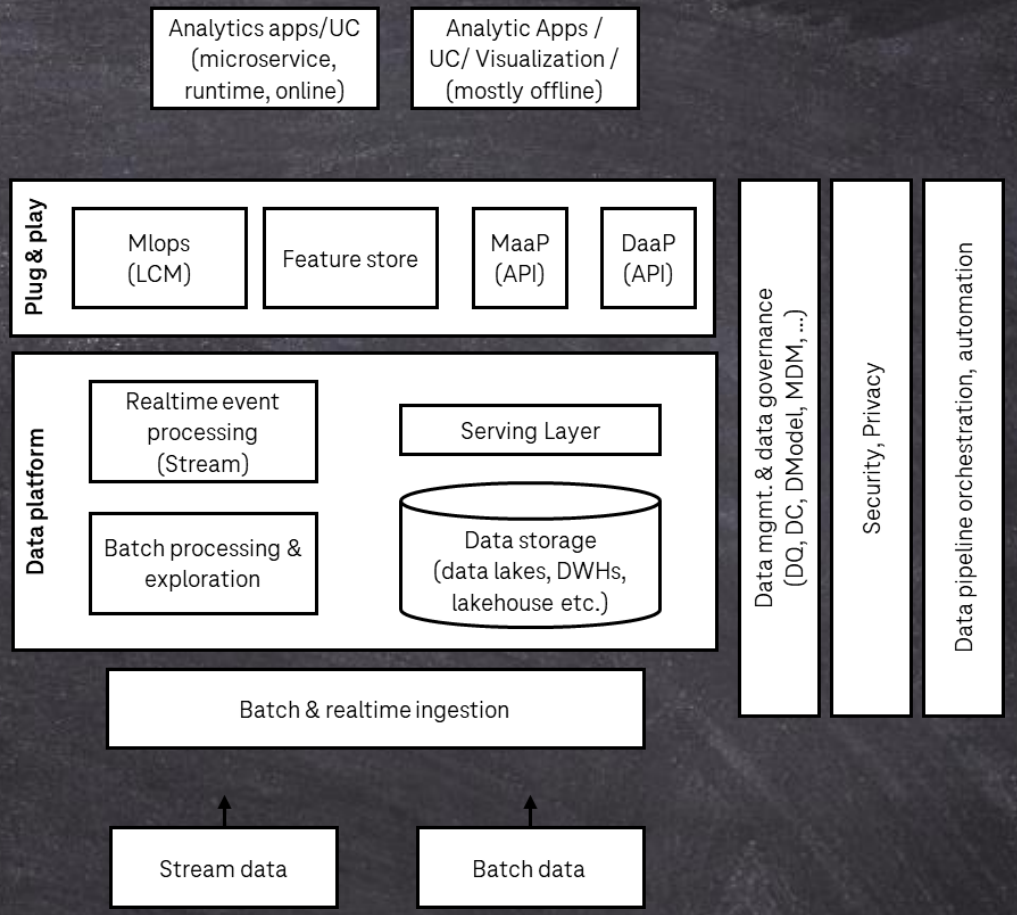
Data Sources, Data Access, Data Quality at the Source

Architecture PiLlars



Architecture PiLlars





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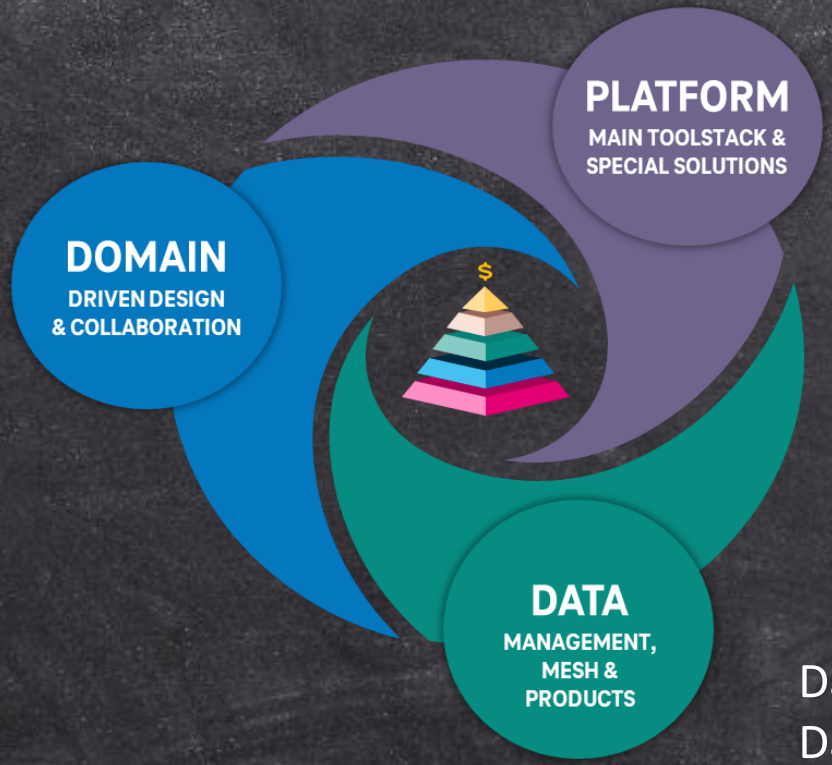
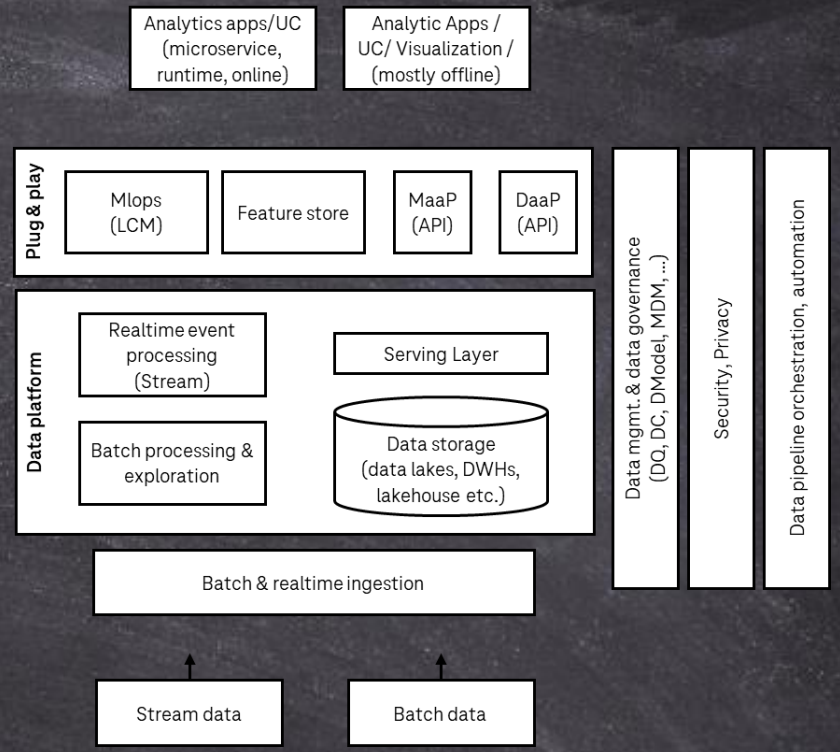
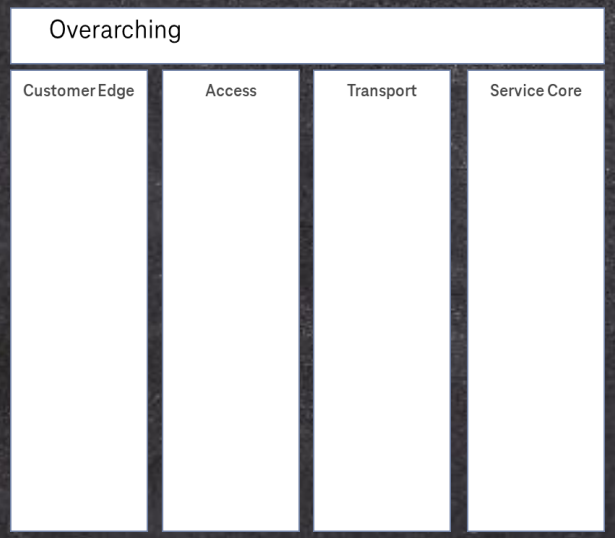
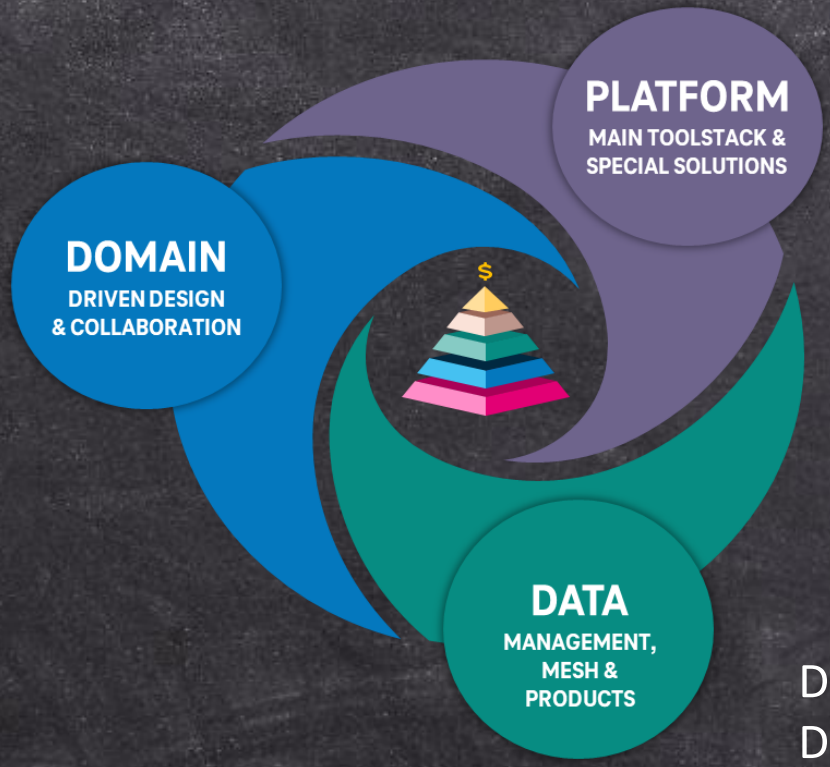


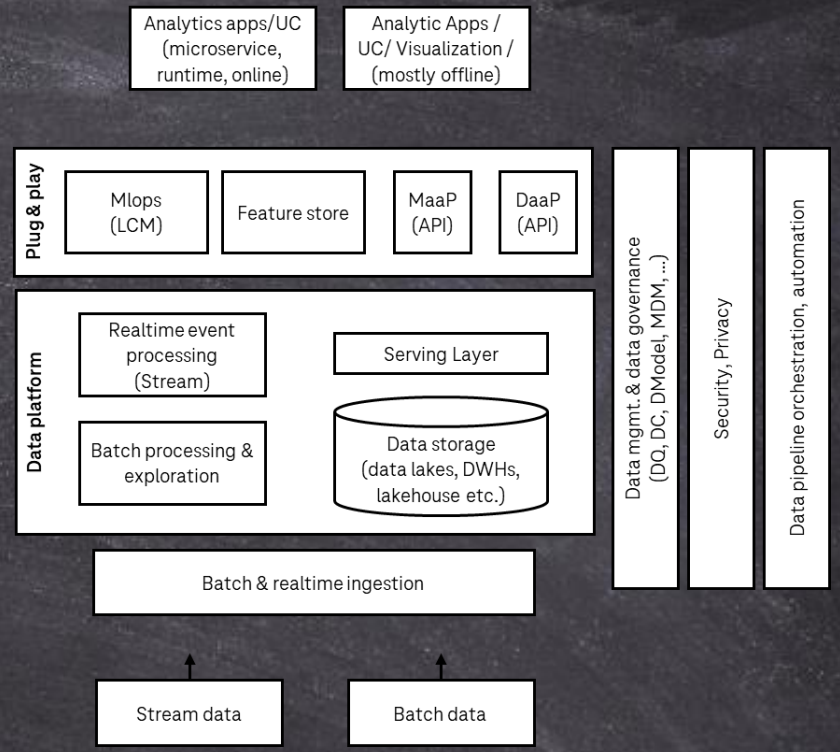


Data Mesh
Data Products
Data Ownership
Common Data Models

Architecture PiLlars







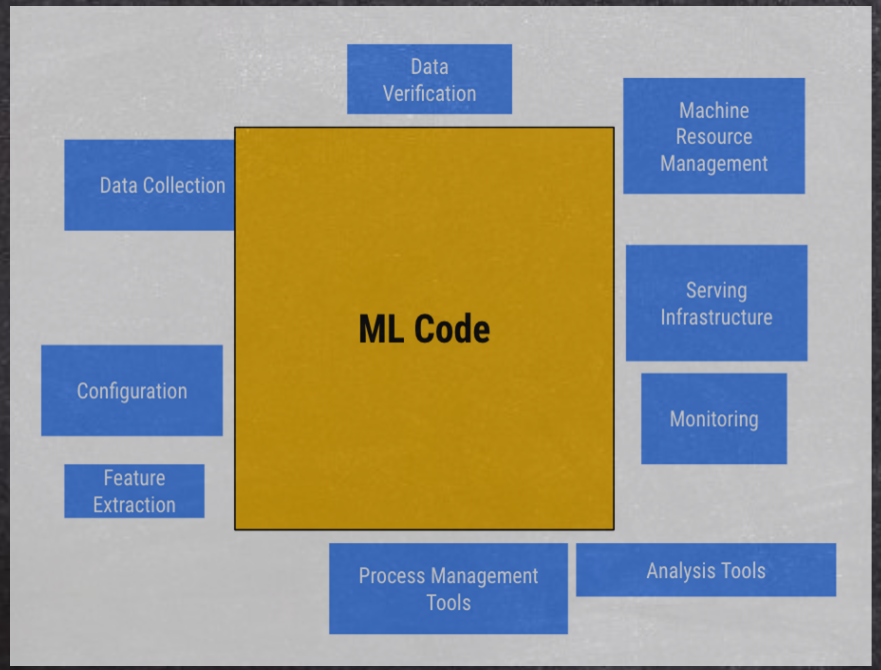
Data Mesh
Data Products
Data Ownership
Common Data Models

Different use case categories have special architecture requirements to fulfill

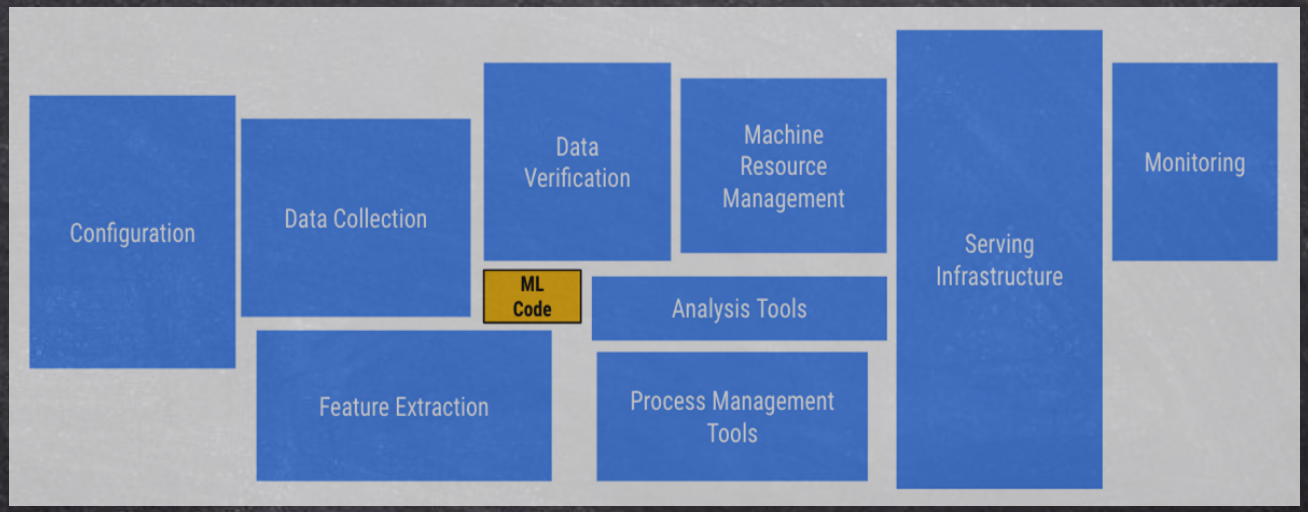
Use case category	Real-time operations / Service delivery	AIOps	Network planning	BI, reporting, process mining	Explorative analytics / playground
Use case examples	Closed loop network steering	Fulfillment, Assurance, power steering	Assisted planning with environment impact / RAN Antenna optimization	Analyzing of process flows, Business-reports	Discovering interdependencies, training AI algorithms, anomaly detection
Requirement examples	99.999 availability, limited outage coverage, integrated in SA/ZTN close to applications	99.96 ! Availability, Essential for 1st Line	External data access, 8x5 availability	Cross Organizational Data, financials, SLA 8x5 but special day time are mandatory	Broad & complete data access, highest scalability, 8x5 availability, longer history of data
Direct Customer impact	high	middle	Low	Low	none

AI Products: Perception versus Reality

- AI Products are mostly about AI/ML
- Team structure reflects perception

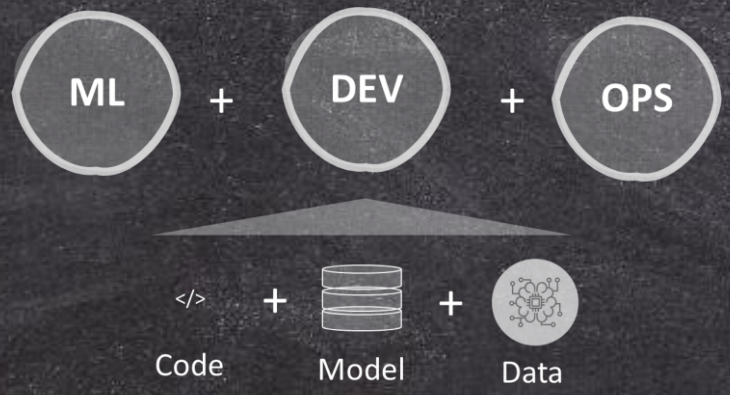


- Building the prototype is often the least costly step of productizing
- Weeks to build AI prototype in notebook
- months to launch on production environment
- ML experts do not have experience with operations



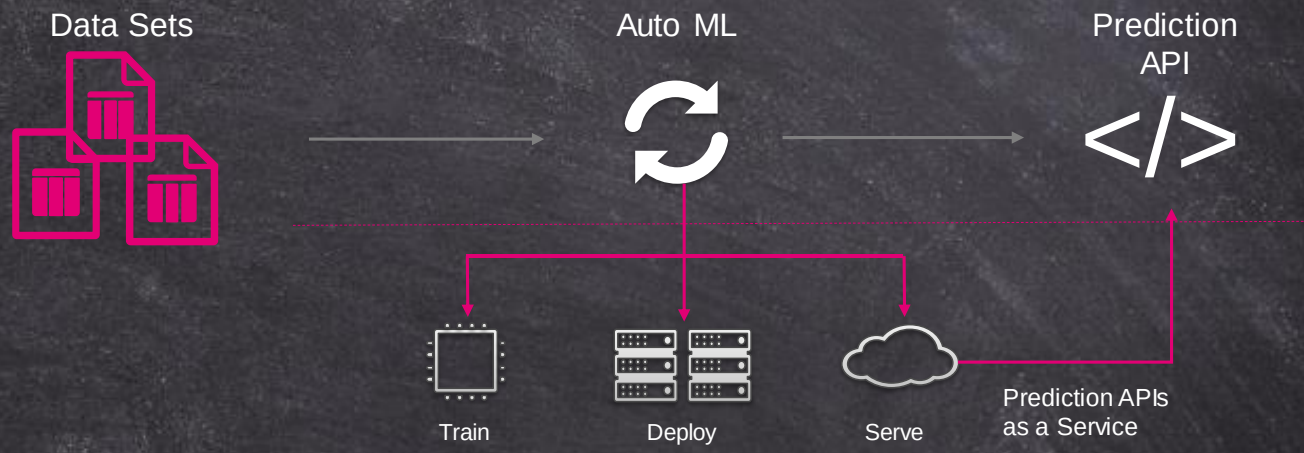
Source: Sculley et al.: Hidden Technical Debt in Machine Learning System

Abstract Data Science frameworks from operational aspects
More focus on automation of ML operation (Mlops)

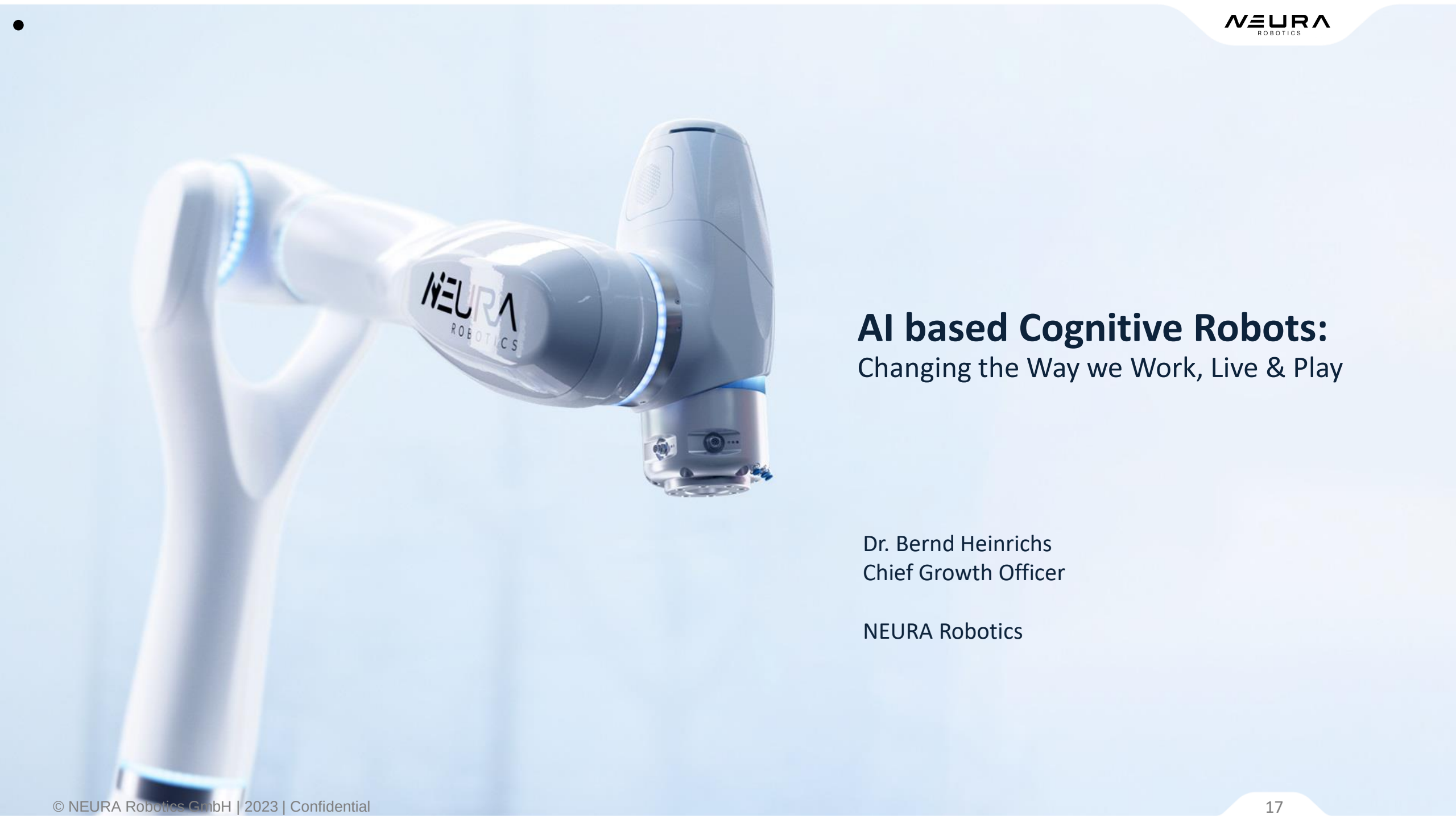


- How to ensure the handover from PoC to operations?
- How to reduce the cost and complexity, while developing the ML use case?
- How to ease the knowledge transfer between Domain experts and ML experts?
- …

Select ML frameworks problem specific
FOCUS on ML Tasks



HIDE Complexity of platform aspects
Train and RUN on best suitable platform
SCALE on shared resources



AI based Cognitive Robots:

Changing the Way we Work, Live & Play

Dr. Bernd Heinrichs
Chief Growth Officer

NEURA Robotics

About NEURA

180+ amazing employees

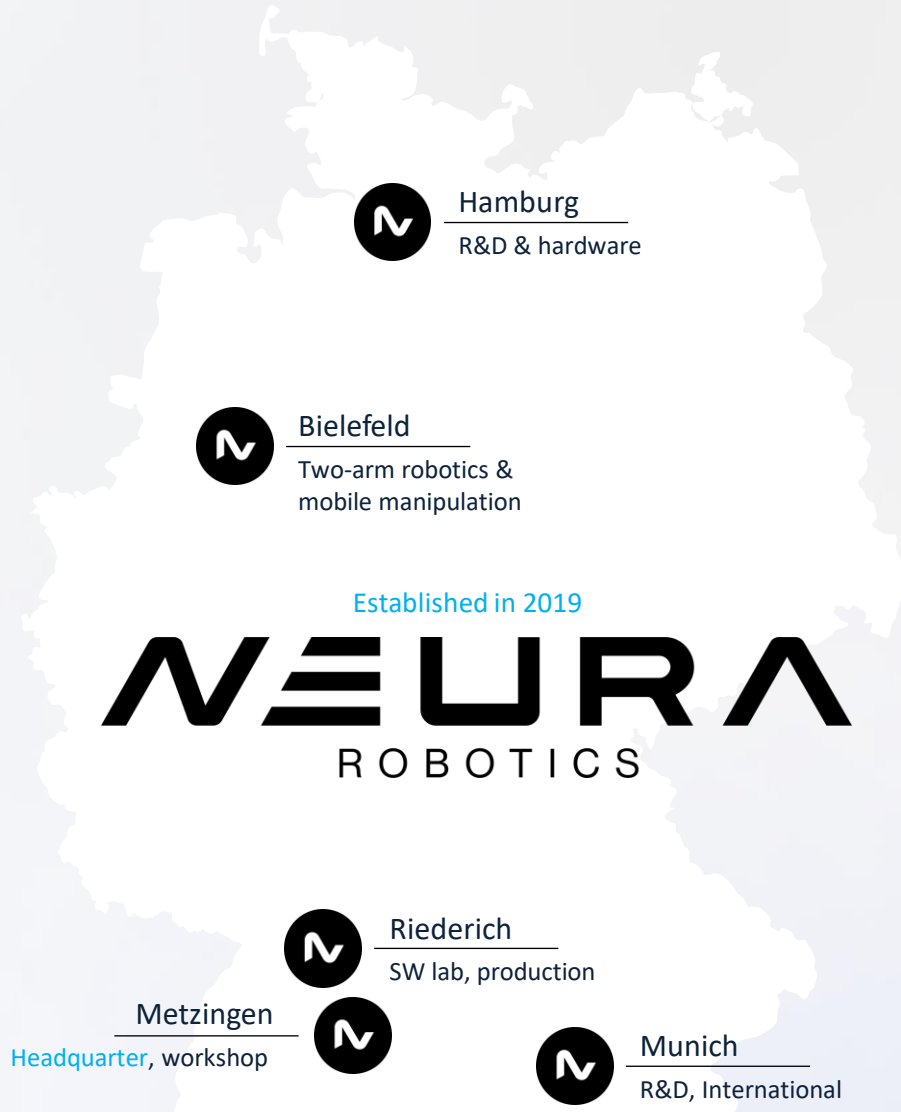
30+ nationalities

Designed & engineered
in Germany

Recent $100+ Mio. USD funding

Patented and pioneering
Technologies

Award-winning products



Intelligent assistants to amplify humanity everywhere & anytime

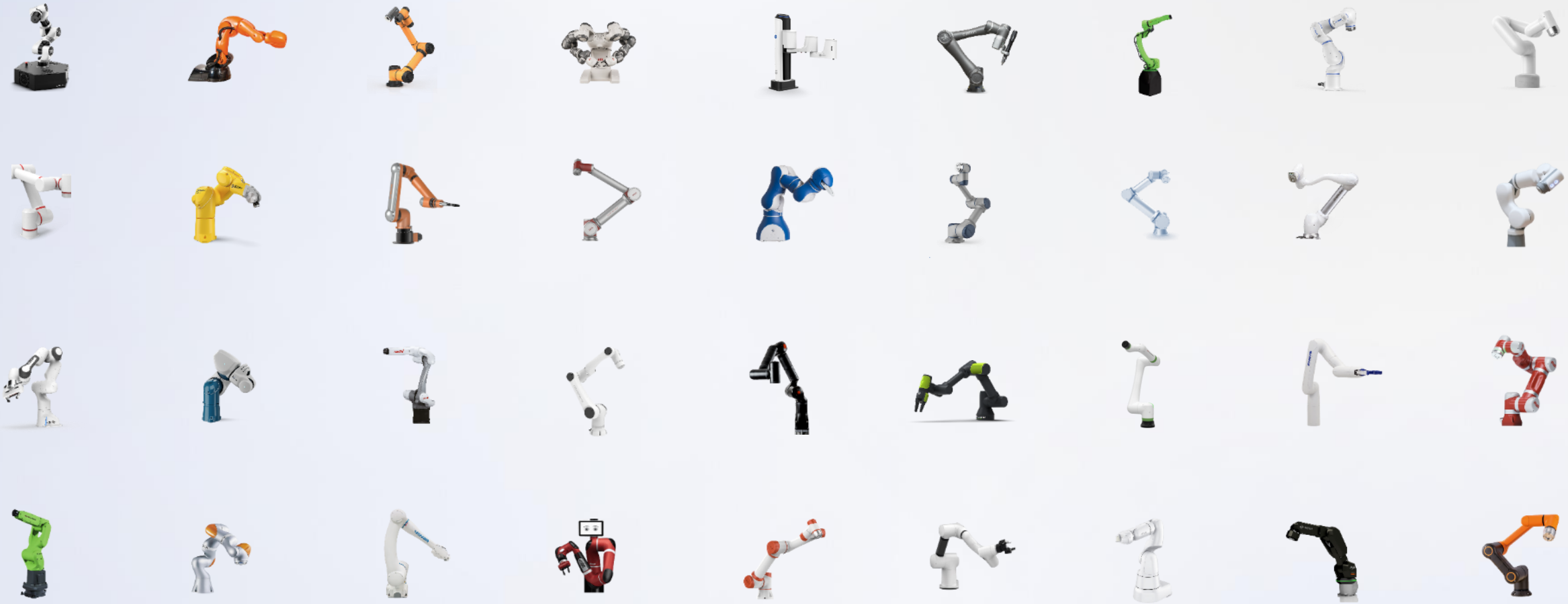
From automation to collaboration

Simple automation

Industrial robots

Collaborative robots

Plenty of cobots to choose from …



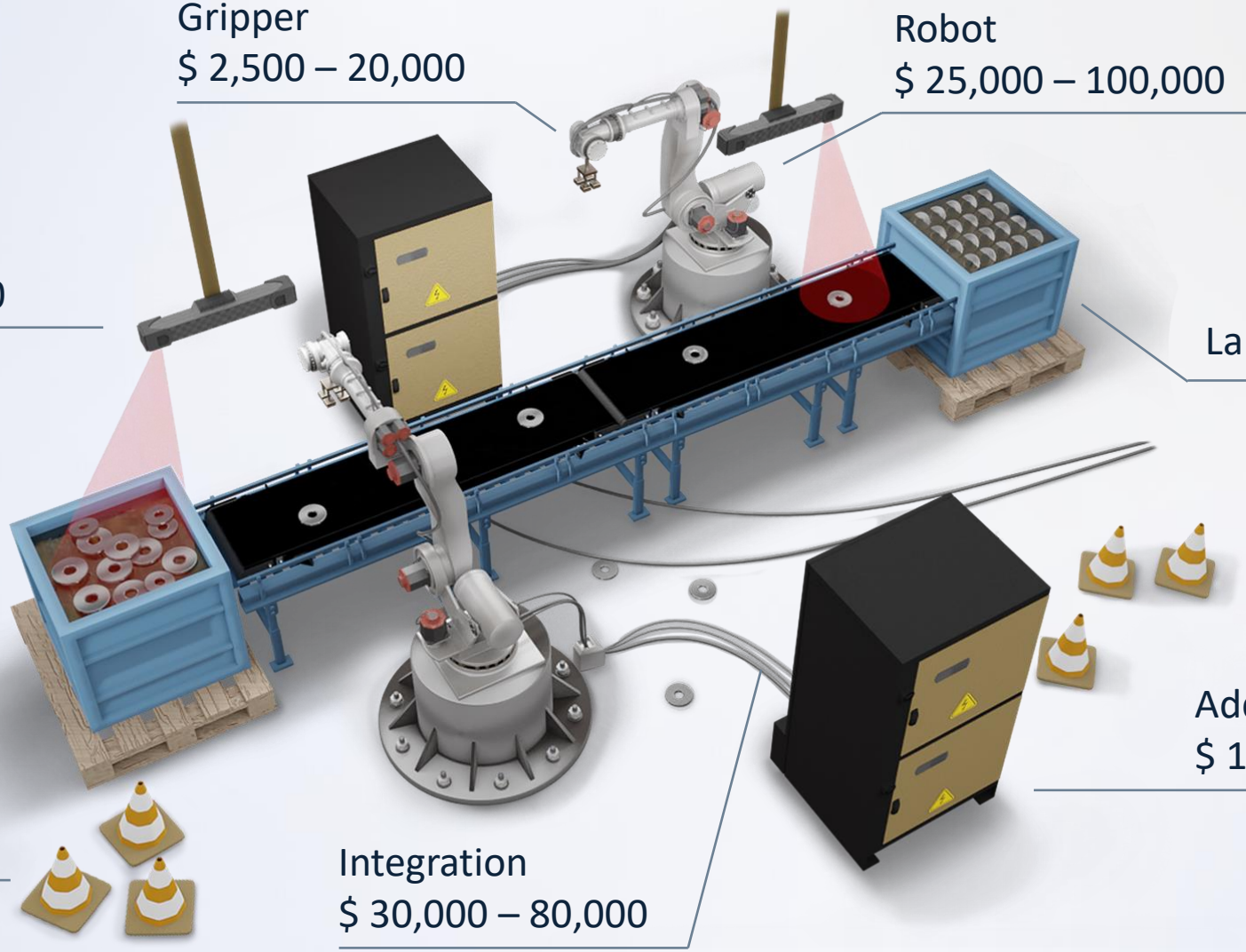
… yet they are far from being truly collaborative

Gripper
$ 2,500 – 20,000

Robot
$ 25,000 – 100,000

Camera
$ 10,000 – 40,000

Large quantities required



Safety rating
$ 5,000 – 20,000

Integration
$ 30,000 – 80,000

Additional software
$ 10,000 – 30,000

Why we don’t have more robots in our lives

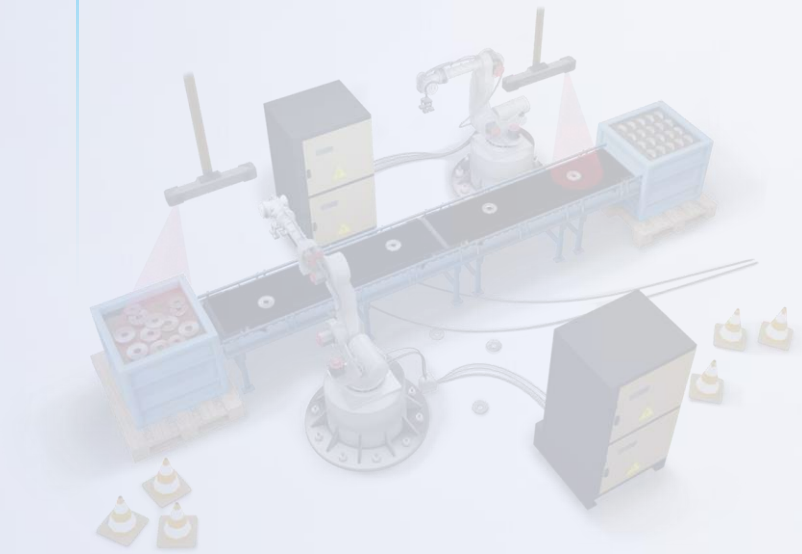
NO FULL AUTONOMY

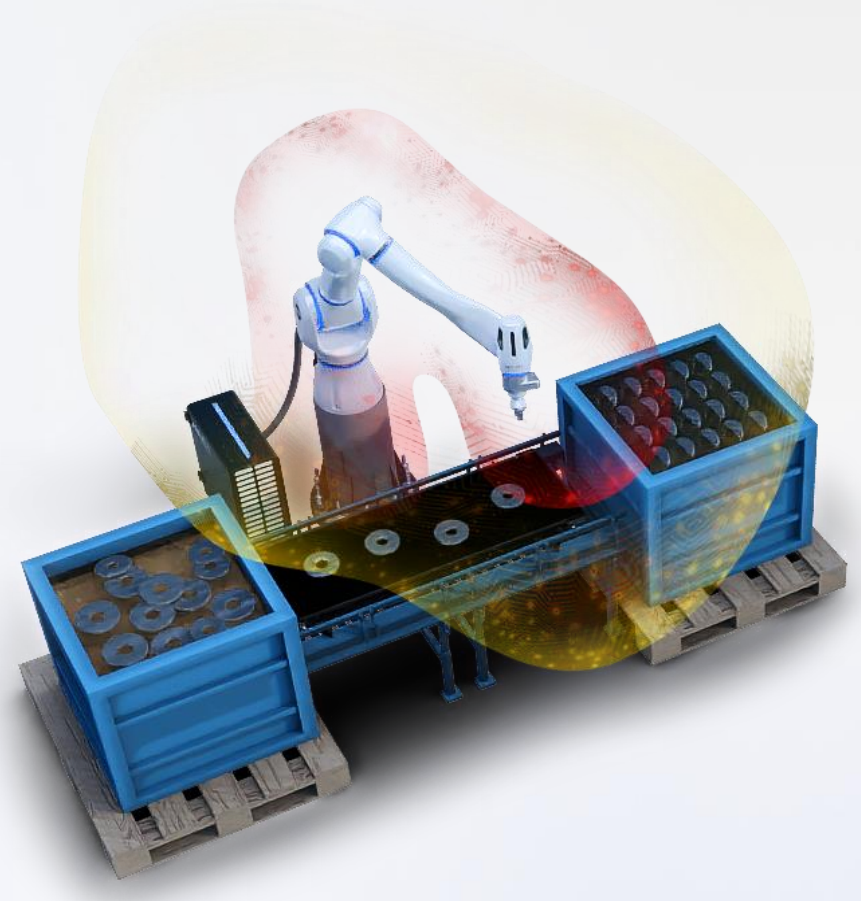
- Retail
- Household
- Hospital
- Elderly care
- Transportation
- Kitchen
- Education
- Farming

- Can’t recognize humans
- No integrated senses
- Not connected
- Unable to predict
- Not affordable

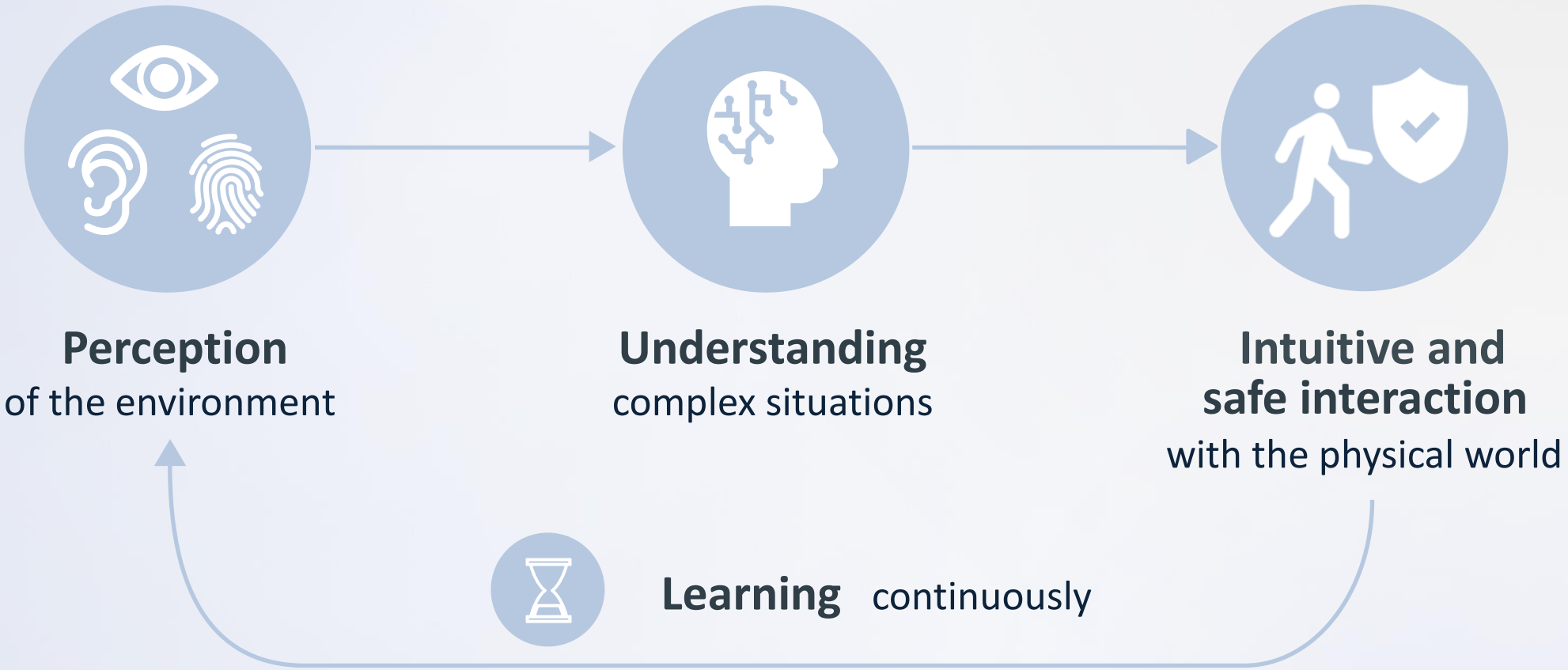
Comprehensive environmental perception and interaction in one device

The future of robotics





Bringing cognitive abilities to robots



Comprehensive portfolio of robotic assistants

MAV®
Multi-Sensing
Autonomous Vehicle

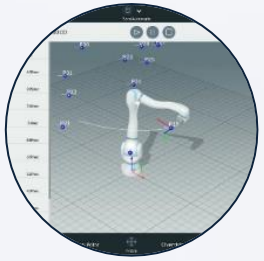
LARA
Lightweight Agile
Robotic Assistant

MAiRA®
Multi-Sensing intelligent
Robotic Assistant

MiPA
My intelligent
Personal Assistant

Creating next-level technology

High performance robot hardware

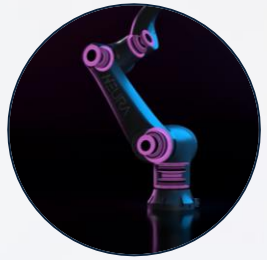


User experience

Advanced motion SW

Artificial Intelligence

Safety architecture



Smart sensors

5G/6G connectivity

Touchless Safe Human Detection technology

Enabling an unprecedented level of interaction between human and robot

Completely safe

- ⇨ TÜV approved concept
- ⇨ PLe Cat.3 / SIL3
- ⇨ Redundant & diverse technology

Precise detection

- ⇨ Recognition of people/individual body parts
- ⇨ Detection of size and speed of people
- ⇨ Multiple meters of range

Unlimited application areas

- ⇨ Can be integrated into any device or as an external device


ROBOTICS

Sneak peak: The future of intralogistics

Advanced AI, 5G/6G connectivity and sensors enable unparalleled interaction and safety

Artificial intelligence
Path optimization, smart interaction

Safe human detection
Touchless sensor technology

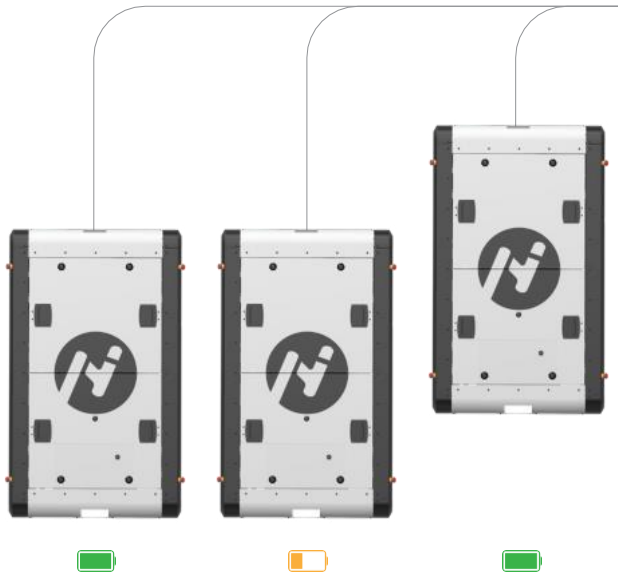
3D voice recognition
Voice commands, identification and tracking

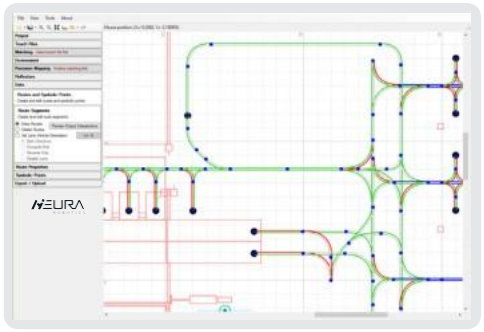
3D vision
Object identification, mapping

5G/6G connectivity
Fleet management, peer2peer comms

Seamless fleet management

Efficiently streamline and control a group of MAVs in any indoor environment





- Dynamic mapping
- Job status
- Real-time monitoring
- Robot location
- Traffic control
- Route prioritization
- Data collection for workflow optimization
- Battery level status


munich
HAHN
HAHN
HAHN
AETURA


JP

The super-brain for a community of cognitive robots

AI Hub

Safe
local cloud

Secure
data transfer

Creating
swarm intelligence


NEURA
ROBOTICS

MiPA

My Intelligent
Personal Assistant

The multi-purpose and intelligent robotic assistant to amplify humanity.

- Multi-modal interaction
- Integrated AI
- Touchless Safe Human Detection technology
- Platform approach: from industrial to private home


NEURA

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Town Hall Innovation Series

TIM slides not included as per speaker request

Harnessing Machine Learning for Enhanced Optical Networks

A State of the Art Update from the IETF and IRTF

Adrian Farrel – Old Dog Consulting

adrian@olddog.co.uk

Daniel King – Old Dog Consulting

daniel@olddog.co.uk

Objectives of This Talk

- Examine the role of Machine Learning (ML) in enhancing fixed networks, crucial in modern telecommunications
- Focus on improving optical network performance, reliability, and scalability using ML, including:
  - *Fault Localisation and Diagnosis*
  - *Capacity Planning and Resource Allocation*
  - *Network Optimisation*
- Highlight the adaptation of the Internet Engineering Task Force's (IETF) Event Condition Action (ECA) framework for optical networks, integrating ML for smarter operations
- Discuss the implementation of ML in optical network management through the IETF ECA framework and YANG models
- Demonstrate industry use cases to show the impact of these technologies on optical network efficiency and their future potential
- Emphasise ongoing ML research and developments by the Internet Research Task Force (IRTF) and engineering efforts within the IETF

Yes, but is it intelligence?

- We try to avoid saying “Artificial Intelligence”
  - A ubiquitous term, too much industry hype, and lack of focus for fixed networks
- “Machine Learning” is a better phrase, but be careful!
  - We are not (yet) talking about algorithms that self-tune
  - We *are* talking about sophisticated algorithms that spot pattens and suggest relationships

Building Blocks

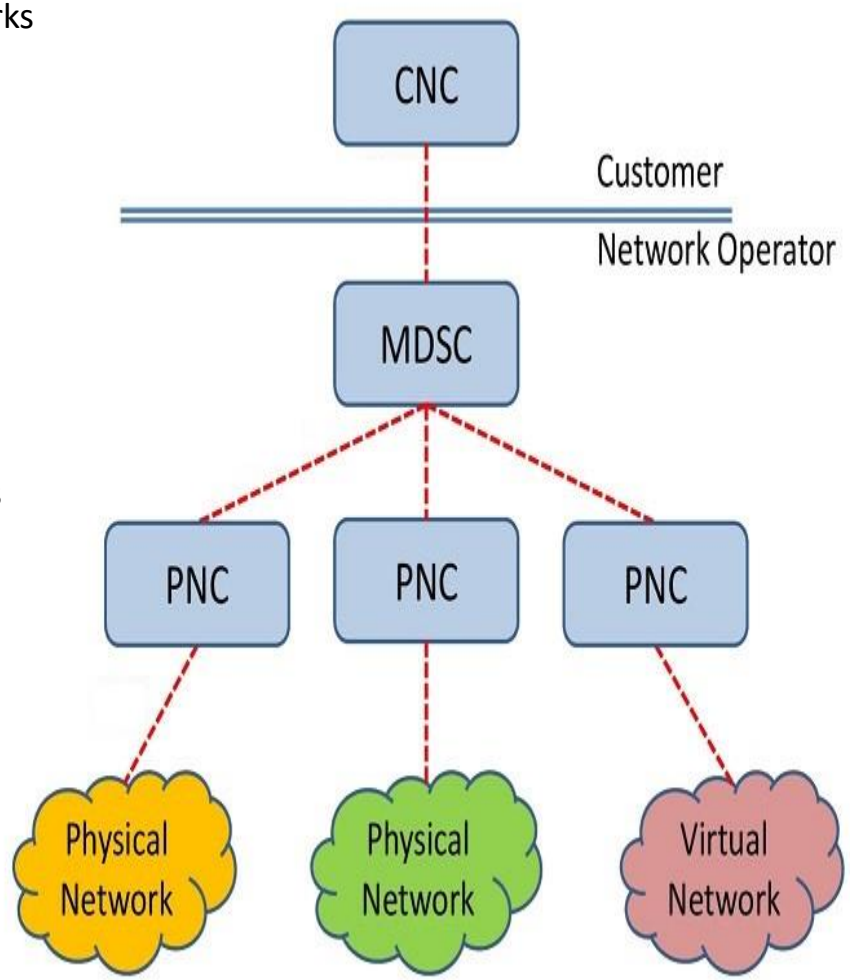
- Optical Fixed Networks
  - Transmission technologies
  - Performance monitoring and fault detection
  - Network control and management
- Management models and systems
  - Architectural models
  - Fine Grain Network Management (FGNM) for optical networks
  - YANG Models
- Convert events into actions
  - Reporting incidents
  - Event Condition Action (ECA) framework
- The ML glue
  - Data profiling
  - Rapid response
  - Predictive actions
- Value add
  - Automating network operation and optimisation
  - Intelligent fault diagnosis and failure prediction
  - Anomaly detection and security hardening

IETF Work on Optical Fixed Networks

- The IETF (Internet Engineering Task Force) is the foremost standards body for Internet protocols and technologies, including those related to optical fixed networks.
- IETF optical work includes:
  - **Generalized MPLS (GMPLS)**: Extending the MPLS protocols to optical networks
  - **Data Modeling for Optical Networks:** YANG modules that model the configuration and operation of optical fixed networks.
  - **Performance monitoring and fault detection**: YANG models for reporting performance monitoring of optical resources
- Recent work in the IETF for optical networks includes:
  - **Abstraction and Control of Traffic Engineered Networks (ACTN):** This framework provides a unified approach to managing and controlling both MPLS and optical networks
  - **Packet-Optical Integration (POI)**: This involves tightly integrating packet and optical layers for more efficient network operation
- The IETF has collaborated with other standards bodies like the ITU-T and OIF to ensure harmonisation and to meet the protocol requirements of future optical technologies

Abstraction & Control of TE Networks (ACTN)

- What is ACTN?
  - A framework for the virtualization and control of multi-domain and multi-layer networks
  - Efficient orchestration of network resources across various technologies, including optical networks
  - *RFC 8453 (framework), RFC 8454 (information models)*
- ACTN for Optical Networks
  - Dynamic provisioning and optimization of optical network resources
  - Creation of virtual network services over physical optical infrastructure
  - Integration of packet and optical networks *draft-ietf-teas-actn-poi-applicability*
- Key ACTN Components
  - Customer Network Controller (CNC): Interfaces with clients to receive service requests and translates them into network requirements
  - Multi-Domain Service Coordinator (MDSC): Orchestrates services across multiple domains, ensuring end-to-end connectivity and performance
  - Provisioning Network Controller (PNC): Manages network resources within a specific domain, executing the commands from MDSC
- Benefits for Optical Networks
  - Enhanced scalability and flexibility through dynamic resource allocation and virtualization
  - Improved efficiency in multi-layer and multi-domain optical network operations
  - Simplified management and operations through centralized control mechanisms with common YANG models

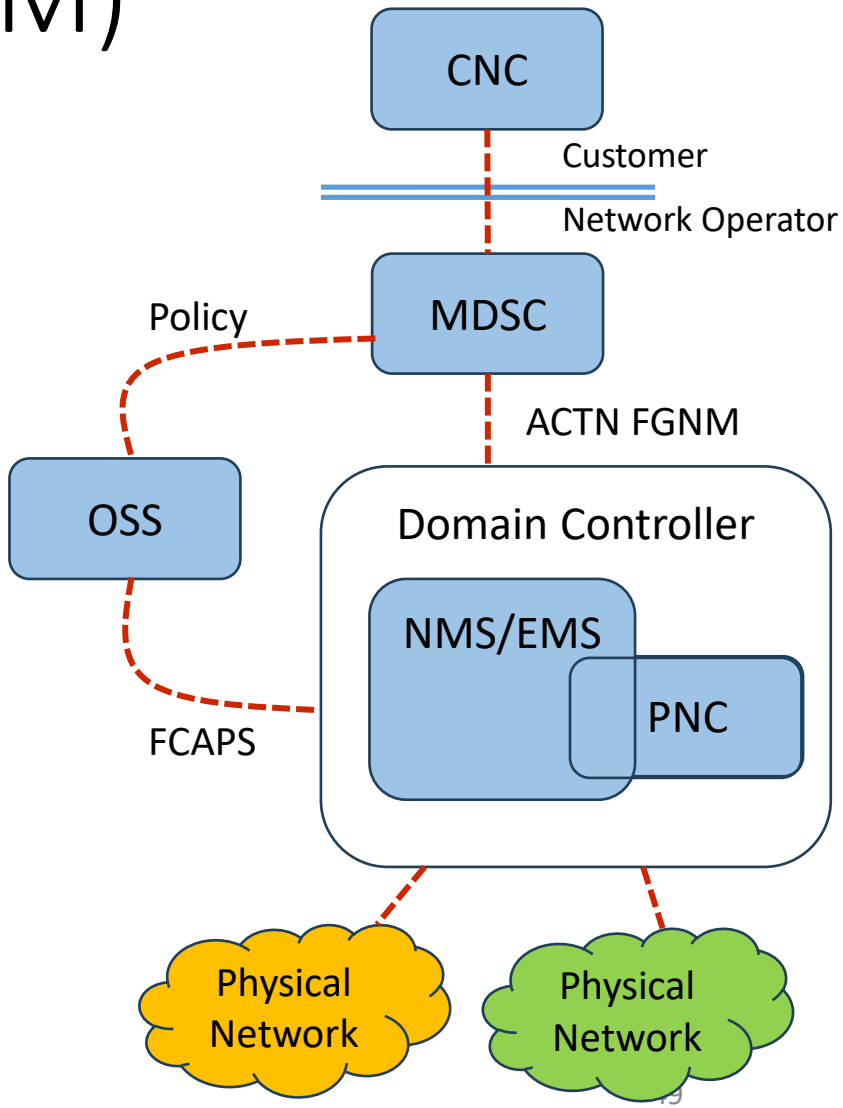


ACTN and CloudCo

- Similar objectives
  - Openness and programmability are key
    - Exposure of external interfaces to allow “plug-and-play” implementations
  - Architectural components may be realised in different places
    - Management systems or network nodes
- Similar functionality
  - Unsurprising as the same features need to be managed
  - CloudCo includes management of VNF and function such as compute and value added services
  - ACTN focusses on connectivity services and designed for recursive applicability
    - Stacked network virtualisation
    - Multiple network technologies
- An interesting project would be to show the integration of CloudCo and ACTN
  - Perhaps that would be a white paper, perhaps a joint IETF/BBF activity
  - A broader IETF picture is “Application-Based Network Operations (ABNO) *RFC 7491*
    - Pre-dates ACTN
    - Includes more functions, but still not a broad as CloudCo

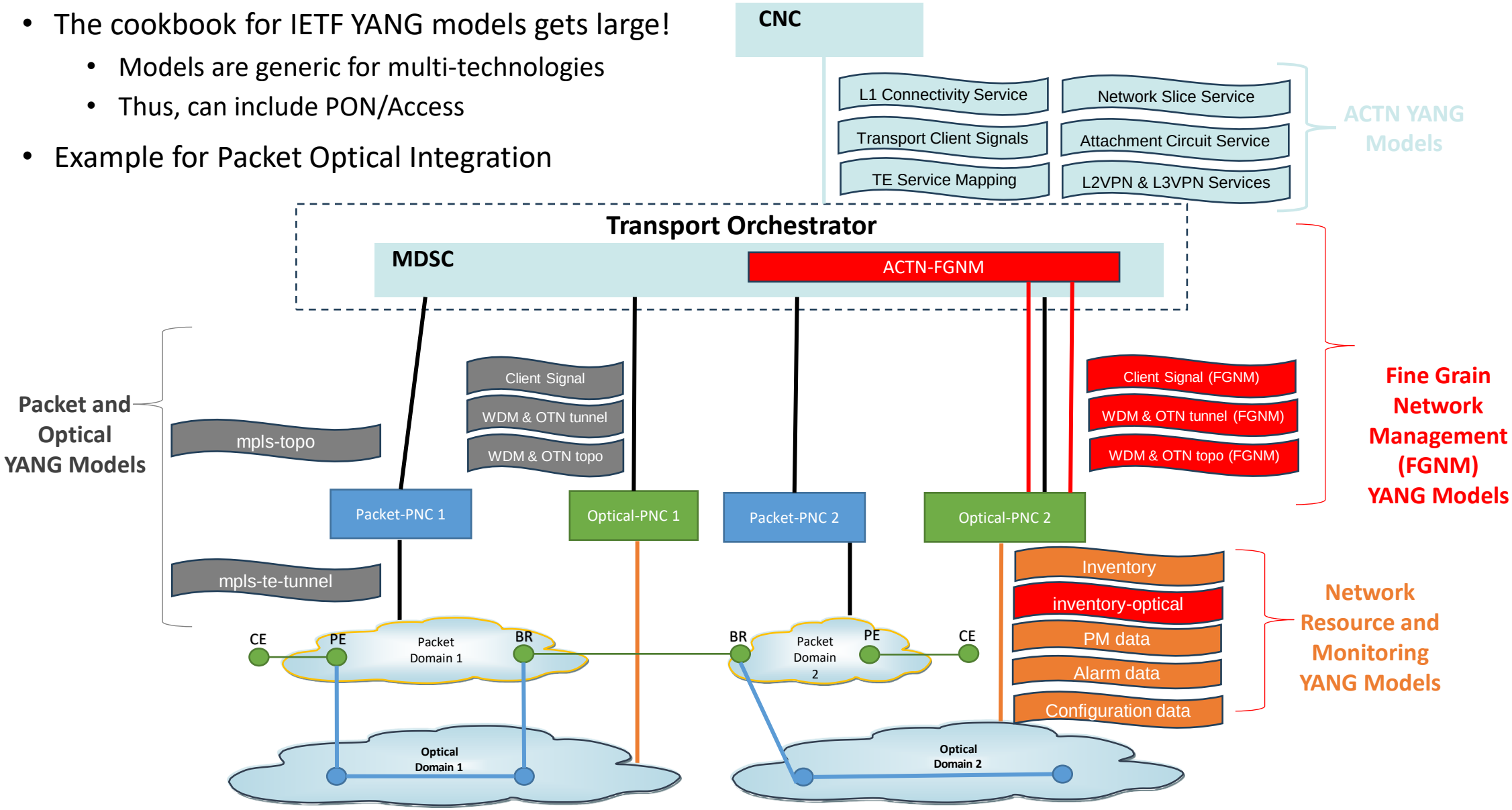
ACTN For Fine-Grain Network Management of Optical Networks (ACTN FGNM)

- Optical networks have been managed using FCAPS systems
  - (Fault, Configuration, Accounting, Performance, and Security)
  - E.g., Multi-Technology Operations System Interface (MTOSI)
  - E.g., Common Object Request Broker Architecture (CORBA)
- Initial ACTN work focused on provisioning and virtualisation
  - No detailed consideration of FCAPS
- But it is easy to integrate FGNM into the ACTN architecture
  draft-gstk-ccamp-actn-optical-transport-mgmt
  - Built on existing IETF YANG models
  - Offers an evolution from MTOSI/CORBA to a full YANG-based management system

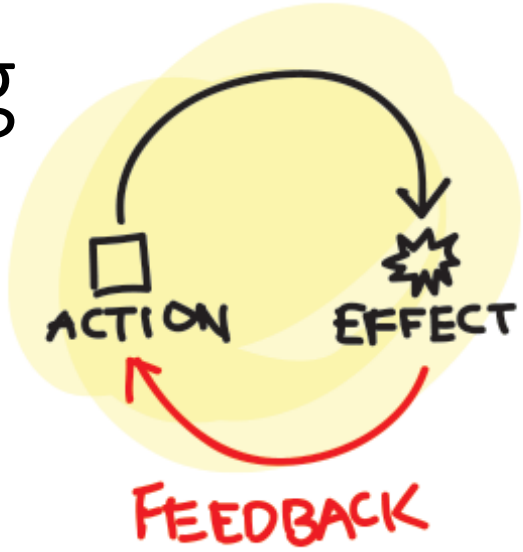


IETF YANG Models for Everything

- The cookbook for IETF YANG models gets large!
  - Models are generic for multi-technologies
  - Thus, can include PON/Access
- Example for Packet Optical Integration



Lessons Learned IETF YANG Modelling



- Base models should be generic and simple
  - Don't try to stick everything in one big model
  - Extend/augment for specific technologies
  - This allows maximal re-use in implementations (simplifies code)
  - Lets multiple vendors use a common base model (proprietary augmentations)
  - In the past, we have not always go this right!
    - Some re-working of IETF models is ongoing
- For example:
  - "A YANG Data Model for Network Inventory" is generic in the IVY working group *draft-ietf-ivy-network-inventory-yang*
  - CCAMP working group is working on optical extensions *draft-ietf-ccamp-network-inventory-yang*
- Also opens up the door for others with specific expertise (e.g., BBF)
- For example:
  - Could construct access-specific models based on (augmenting) the IETF models

What is a Network Incident?

- Everyone has terminology
  - Many SDOs have used different terms to describe events in the network
  - No one agrees perfectly
- Why have *n* sets of terms when you can have *n+1* ?
  - The IETF needs a reference terminology
  - Stake in the ground at *draft-davis-nmop-incident-terminology* (work in progress!)
  - Some key terms
    - Resource, State, Condition, Change
    - Event, Incident, Problem, Cause
    - Alert, Notification, Alarm
- Where can I go to find out about network incidents?
  - Need a common YANG model for network incident management
  - *draft-feng-opsawg-incident-management*
  - Some key concepts
    - Trouble ticketing
    - Multi-layer coordination
    - Incident identification / diagnosis / resolution

Event-Condition-Action

- An Event Condition Action (ECA) framework with a YANG model is being developed in the IETF
  draft-ietf-netmod-eca-policy
  - **Event**: A significant change or occurrence within a system
    - In optical networks, an Event might be a sudden spike in data traffic or a drop in signal quality
  - **Condition**: A Condition is evaluated after an Event to determine whether an action should be taken
    - This is a predefined rule or set of criteria that must be met for the system to proceed with a response
  - **Action**: An action is executed in response to an Event if a Condition is met
    - Actions are predefined responses designed to address or mitigate specific Events under certain Conditions
    - In optical networks, Actions might include rerouting data traffic, adjusting bandwidth allocations, or initiating a maintenance protocol

Putting the Building Blocks Together

- We have an architecture for top-to-bottom optical network management
- We have a fine-grained and detailed set of control, configuration, and management YANG models
- We can report and inspect “incidents”
- We can apply an ECA model to iterate through configuration and control to resolve or bypass network problems
- Now we can talk about integrating with Machine Learning
  - Management System and YANG and ECA and ML = Automation of Network Operations
    - Enables automation of routine tasks and decision-making processes
    - Leads to more efficient and rapid network operations
    - Enhances the system's ability to self-manage, adapt to changes, and maintain high levels of performance and reliability without constant human intervention

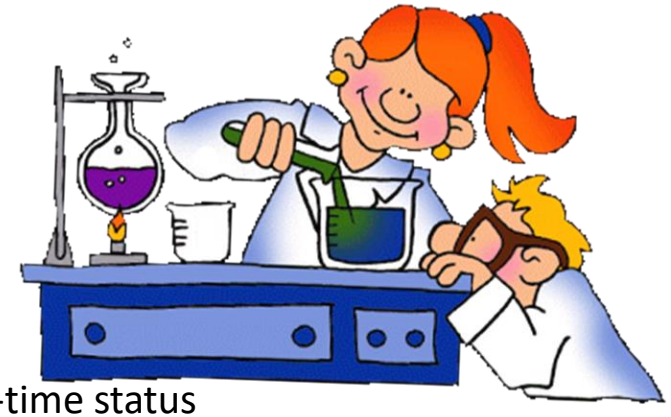
What Do We Want ML To Do For Us?

- Capacity Planning and Resource Allocation (Predictive Provisioning)
  - Optimise the allocation of network resources by predicting traffic patterns and dynamically adjusting bandwidth and routing to ensure efficient use of the network infrastructure. This helps manage peak traffic loads while maintaining service quality.
- Network Optimisation
  - Analyse vast amounts of data from network operations to identify optimisation opportunities, such as adjusting modulation schemes or power levels to maximize data throughput and minimize errors.
- Predictive Maintenance
  - Analyse historical data and real-time performance metrics to predict potential failures or degradation in network components before they occur. This allows for proactive maintenance, reducing downtime and service disruptions.
- Anomaly Detection
  - Continuously monitor network traffic and performance, identifying anomalies that could indicate security breaches, faults, or failures. Early detection enables swift responses to mitigate issues.
- Fault Localisation and Diagnosis
  - When a problem occurs, ML can help quickly pinpoint the exact location and likely cause of the fault, significantly reducing the time and effort required for troubleshooting.
- Security Enhancements
  - ML can improve network security by identifying patterns indicative of cyber threats, such as Distributed Denial of Service (DDoS) attacks and initiating appropriate countermeasures.

Example Use Case: Fault Localisation and Diagnosis

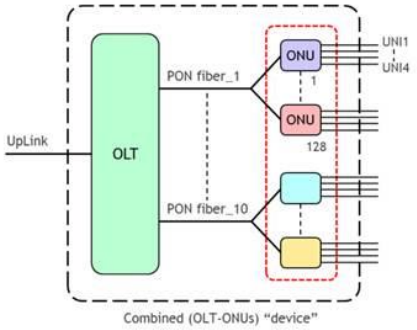
- ML can analyse patterns in historical and real-time data
  - Identify anomalies
  - Predict potential faults before they cause significant disruption
  - Diagnose the root cause of issues
- **Data Collection**: Collect data from various sources within the fixed network, including performance metrics, logs, error messages, inventory, and network topology information
- **Model Training:** Use historical data, including instances of known faults and their characteristics, to train ML models
- **Anomaly Detection:** Deploy the trained models to continuously monitor the network in real-time. The models can detect anomalies in the data that deviate from normal operational patterns, potentially indicating a fault.
- **Fault Localisation:** Once an anomaly is detected, further analysis is conducted to localize the fault. Correlating the anomaly with specific network elements (like fibre links, amplifiers, or switches) and using the network topology to pinpoint the fault's location.
- **Actionable Insights:** Provide detailed insights and recommendations to network operators, including the fault's location, probable cause, and suggested remedial actions.
- What are the benefits?
  - Reduced Downtime: Faster fault localisation and diagnosis lead to quicker resolution times
  - Proactive Maintenance: Predictive capabilities can identify issues before they lead to failures.
  - Operational Efficiency: Automating the fault localisation and diagnosis process reduces the need for manual intervention.
  - Improved Reliability: Enhancing fault management processes contributes to overall network and service reliability.

Ongoing Research and Next Steps



- Early work is happening in the IETF and IRTF
  - Digital Twin or Digital Map
    - Model the existing network in software to make predictions, experiment, see real-time status
      draft-irtf-nmrg-network-digital-twin-arch, draft-havel-opsawg-digital-map
    - Optical Digital Twin is TBA
  - Control and management of optical pluggables
    - How do pluggables fit into the inventory and the management system?
      draft-davis-ccamp-photonic-plug-control-arch, draft-poidt-ccamp-actn-poi-pluggable, draft-poidt-ccamp-actn-poi-pluggable-usecases
  - Security hardening for optical networks
    - How can the management, control, and operations of optical networks be made more secure?
      draft-doolan-ccamp-saoc-in-actn-poi, but mainly TBA
- Cooperative work with BBF
  - Liaison on “ONU Management at Scale”
    https://datatracker.ietf.org/liaison/1850/
  - Liaison on “Network Resource Model (NRM)”
    https://datatracker.ietf.org/liaison/1895/

The goal of the WT-505 project is to develop an *ONU management model* that scales efficiently for OLT-ONU Combined NE mode



OLT-ONUs as a single large device

Dimension example:

- 3 VLAN interfaces per UNI
- 4 UNIs per ONU
- 128 ONUs per PON
- 10⁺ PONs per OLT

This results in 15K⁺ interfaces, just on the ONU side. Moreover, each of these interfaces has a counterpart on the OLT side resulting in a grand total in the combined model of 30K⁺ interfaces related to ONUs.

How to Influence the IETF Work

- The IETF is, of course, interested to hear from the BBF
  - What existing work is relevant? What work is ongoing? What is the IETF doing wrong?
- Liaisons are often sent to the IETF to expose work and opinions
  - We could make more use of liaisons to work cooperatively
- Individuals are free to participate in the IETF
  - All mailing lists are open, anyone can sign up
  - All opinions and thoughts are welcome
    - They are received as the contributions of individuals
- Bigger ideas can be submitted as Internet-Drafts
  - Just write it, post it, and discuss it on a mailing list
  - The IETF works on architectures, protocols, and external interfaces, NOT algorithms
- Where do you start?
  - Just ask! Most IETFers will try to give you pointers
  - Adrian and Daniel are always willing to help
- Some Relevant Working Groups and Research Groups
  - TEAS – ACTN and common service YANG models
  - CCAMP – Anything specific to optical networks
  - OPSAWG – Anything general about network operations
  - NMOP and IVY – New working groups for network management and inventory
  - ANIMA – Autonomic networking
  - NMRG – Research work related to network management

Any (more) questions?

Any follow-up questions or requests, please contact:

Adrian Farrel – Old Dog Consulting

adrian@olddog.co.uk

Daniel King – Old Dog Consulting

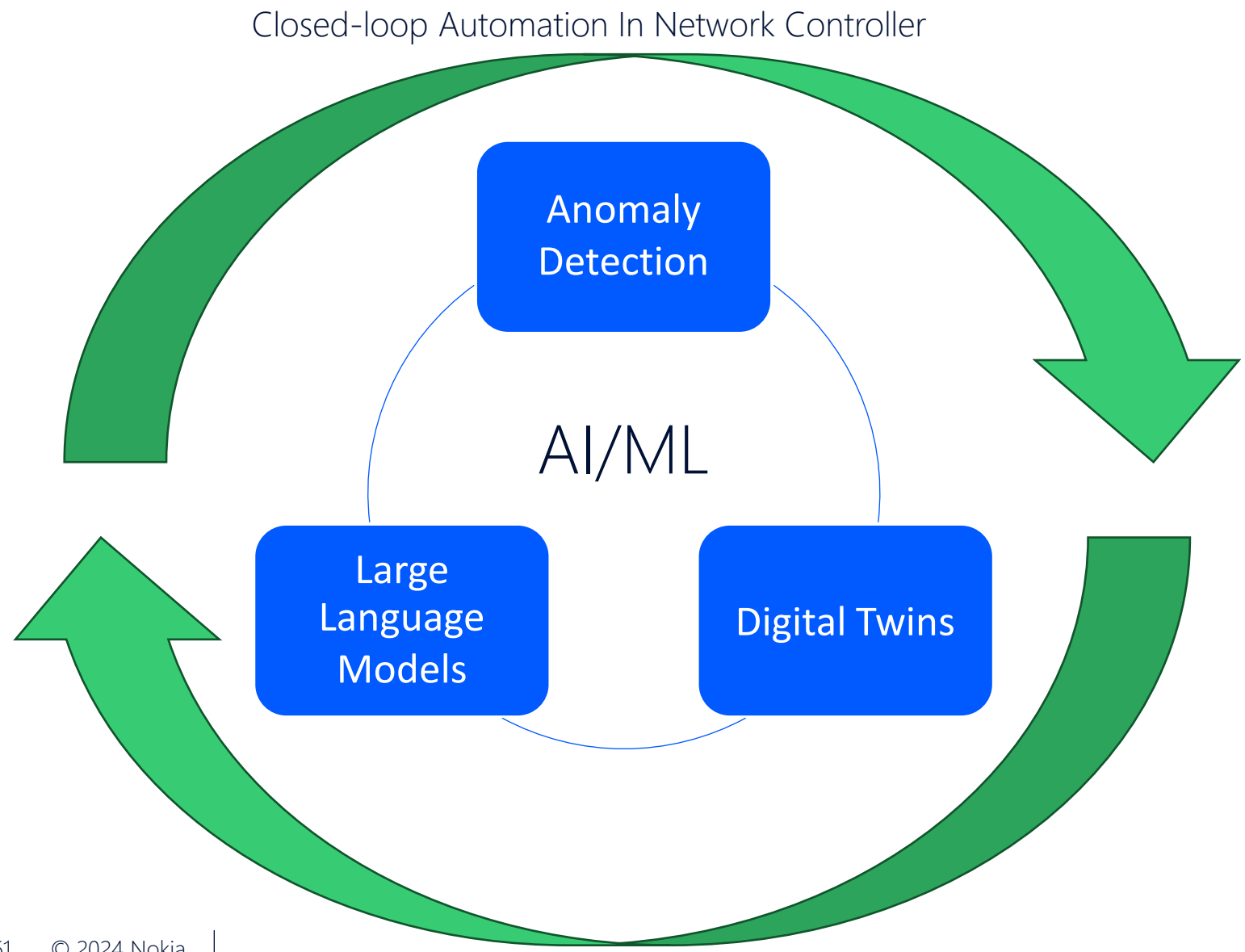
daniel@olddog.co.uk

AI/ML for Access Network

BBF TownHall Innovation Session
March 4th, 2024

Benoît Drooghaag
AI/ML Application Expert
Nokia

AI/ML in Access Network



Not only for controllers

- Field forces (computer vision)

- Helpdesk & Troubleshooting (alarm correlation, RCA workflow optimization)

Automated time-series based anomaly detection

PM data telemetry

Subscription model with dynamic collection intervals

KPI calculator

Derive your own metrics to be monitored

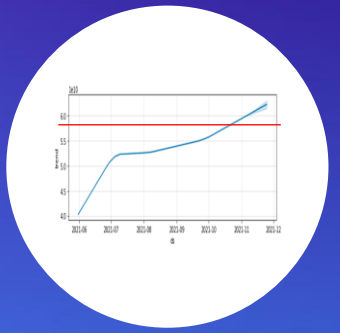
Behavioral model

Retrained periodically based on latest data set

Prediction engine

Anomalies deviating an expected range are identified

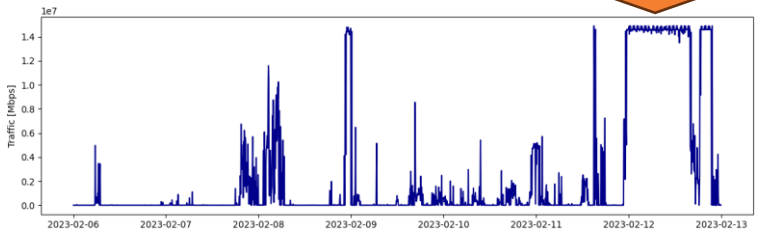
Proactive remediation



Data visualisation layer and alarm notification triggers

Anomaly Detection – Nothing without RCA workflow & CLA

Anomaly detected in traffic trace



Plateau = Service tier limit

- Recommend service upsell
- Automated service campaign

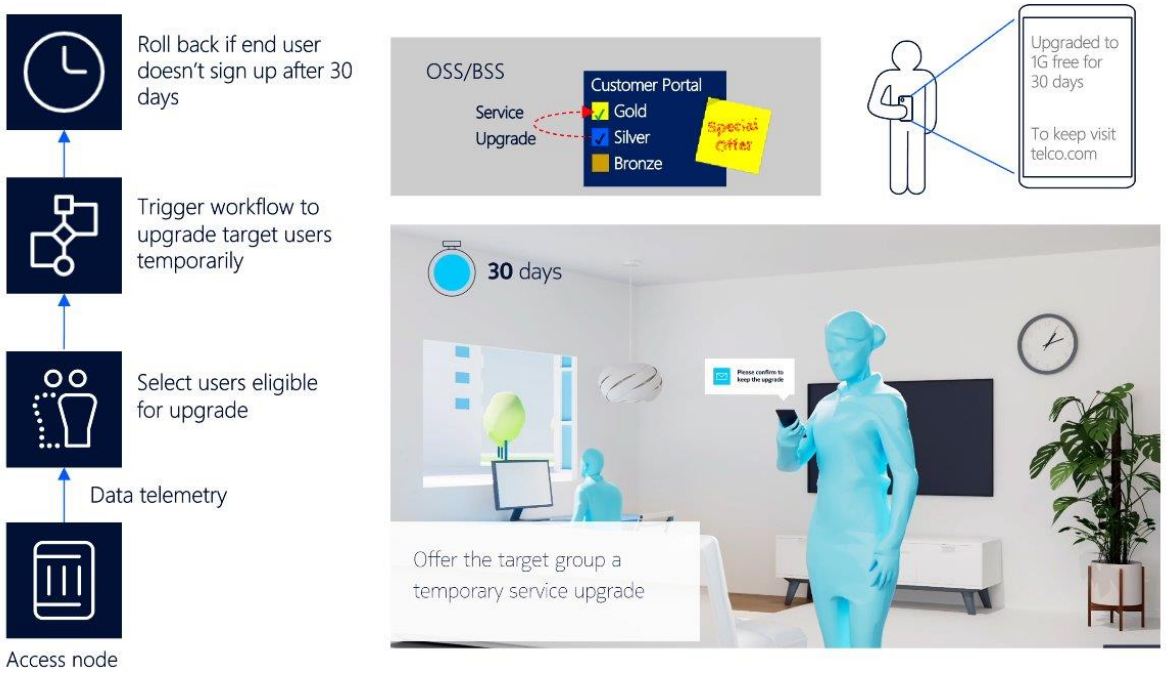
Congestion in PON or Uplink

- Technology Upgrade
- Dynamic Bandwidth Sharing Optimization

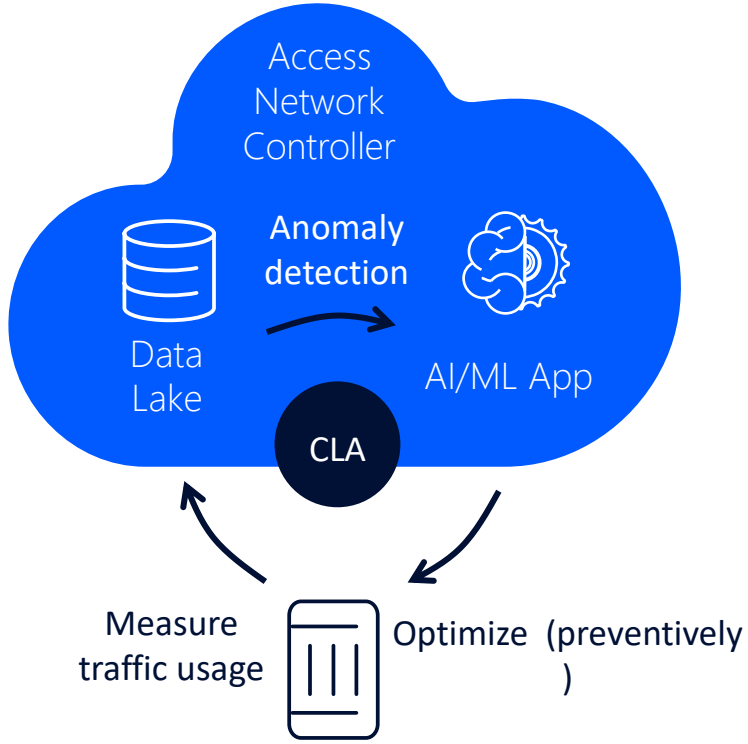
- E2E diagnosis triggering

CLA concrete use cases

For Upsell Campaign management

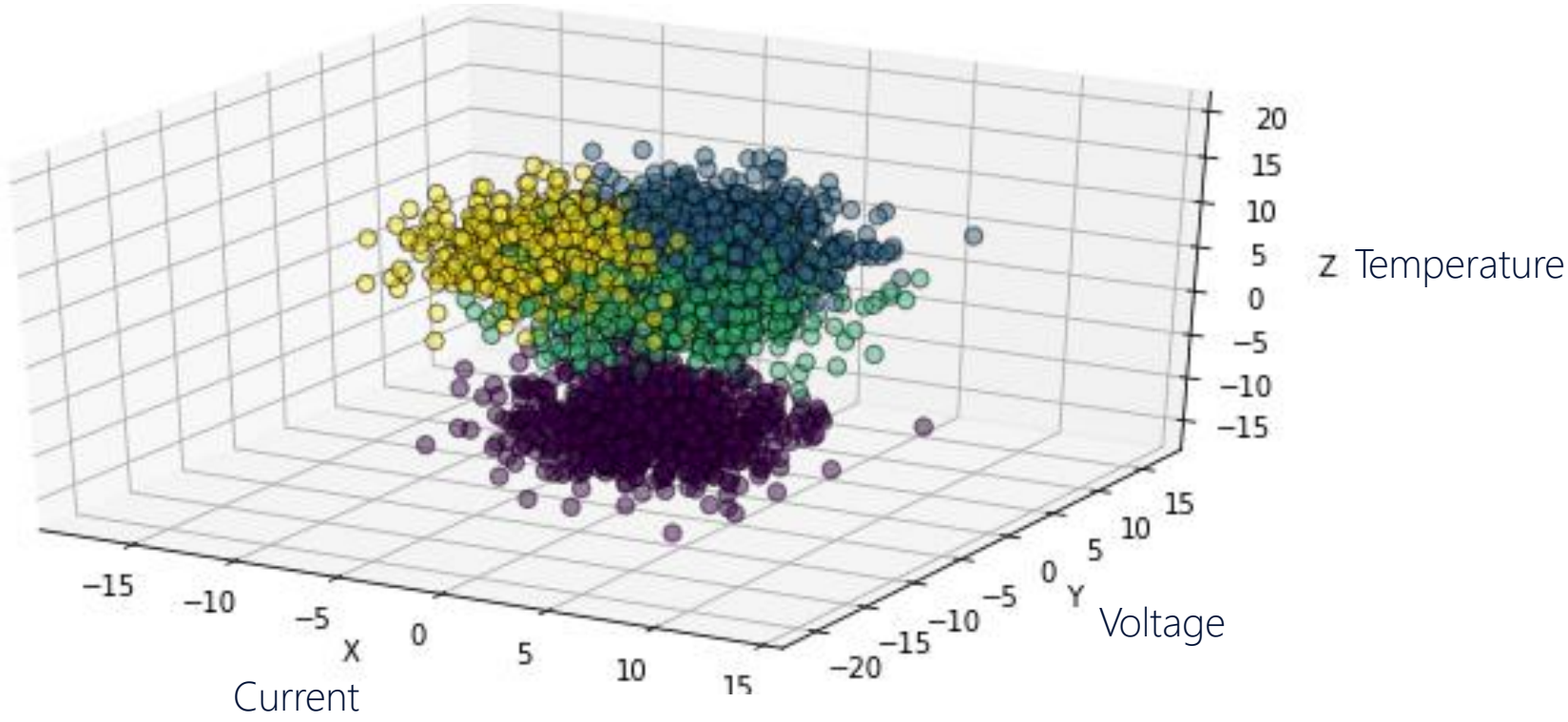


Dynamic PON bandwidth management for highly loaded PONs



Anomaly Detection

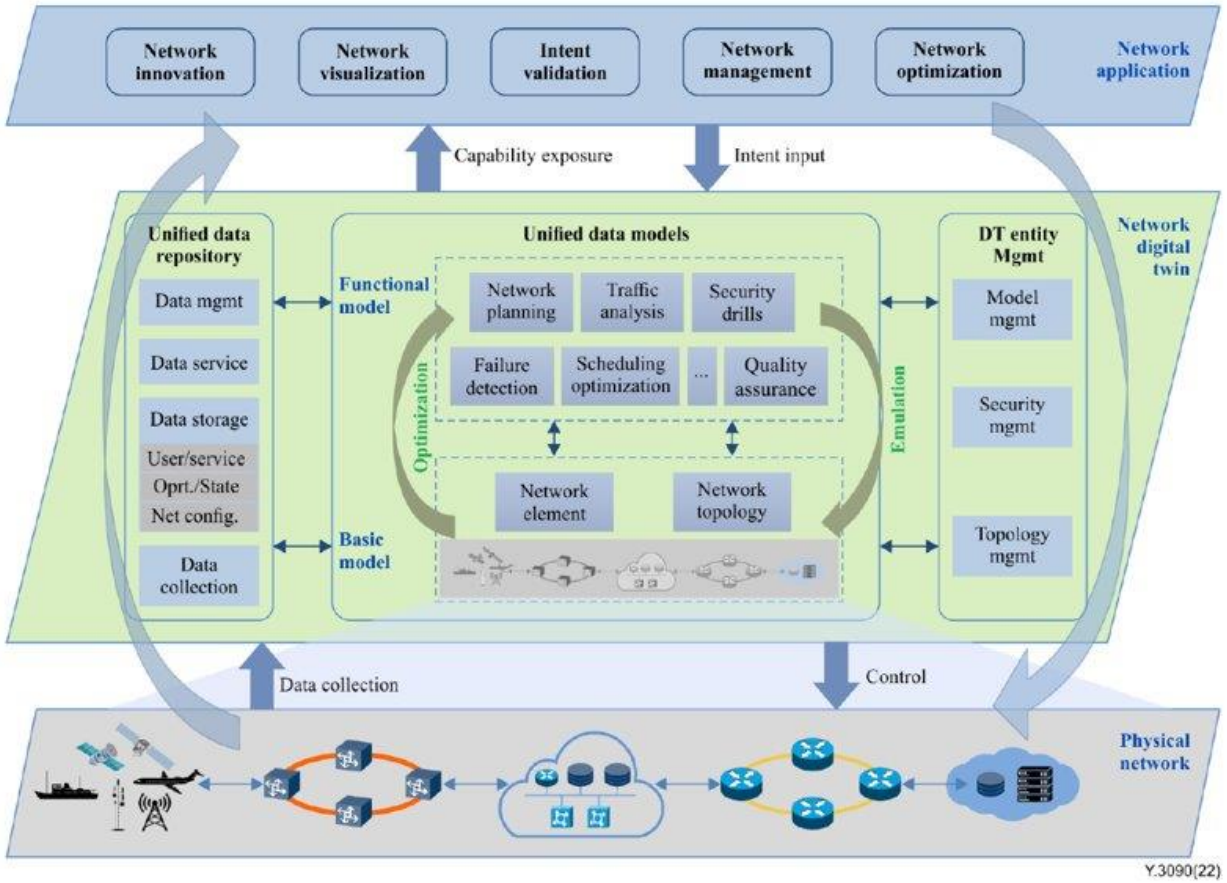
- Not only for single-variate time-series
- Multi-variate example (1 timestamp) : SFP data (illustration pic)



Color = SFP model

Digital Twin

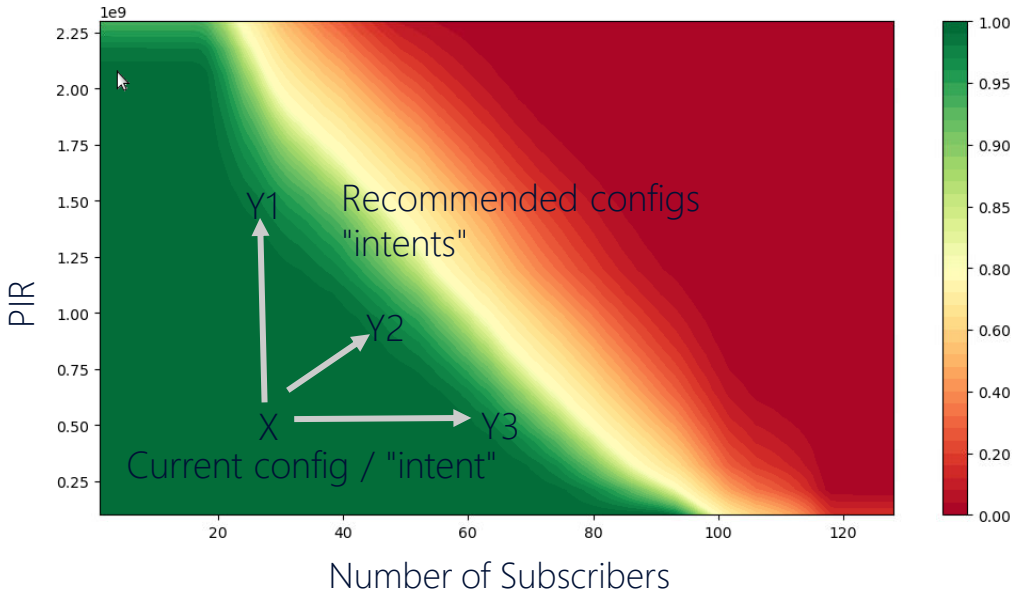
ITU Y.3090 Digital Twin Network



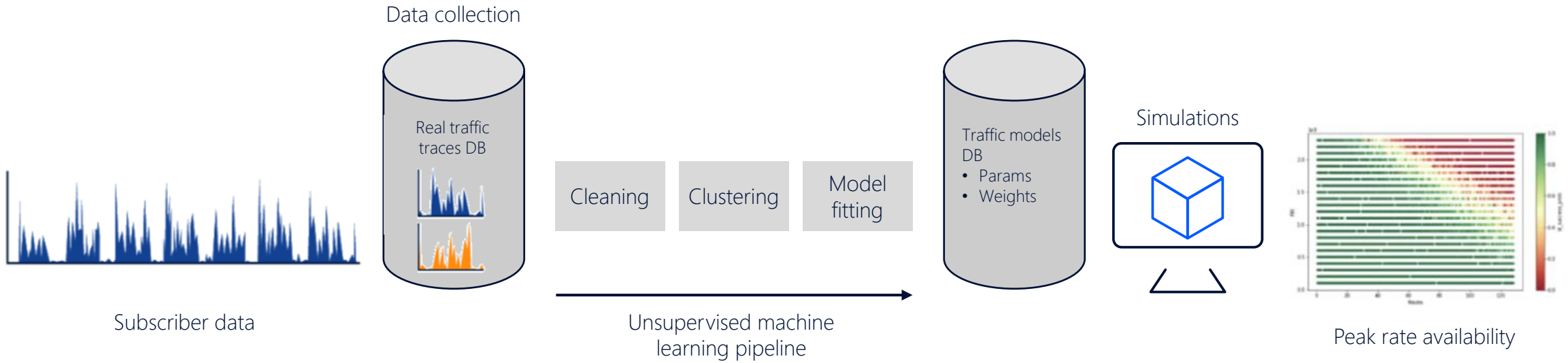
Application to PON Network Planning & Capacity Management

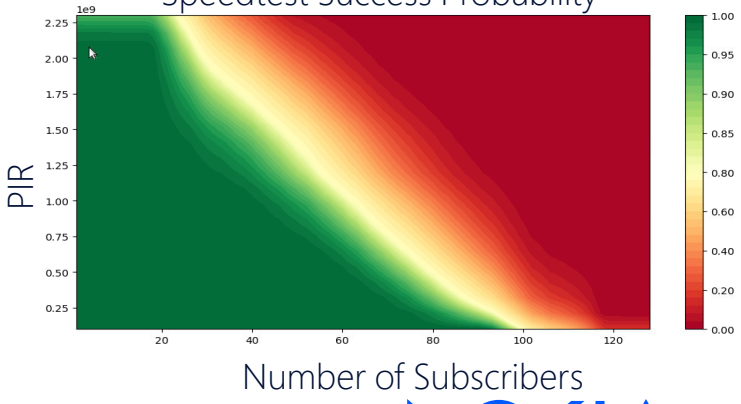
Can I offer 1Gbps to my GPON users today ?
Can I increase the number of subs per PON ?
Will it still be OK in 3 years ?

Speedtest Success Probability



Digital Twin for traffic engineering use cases

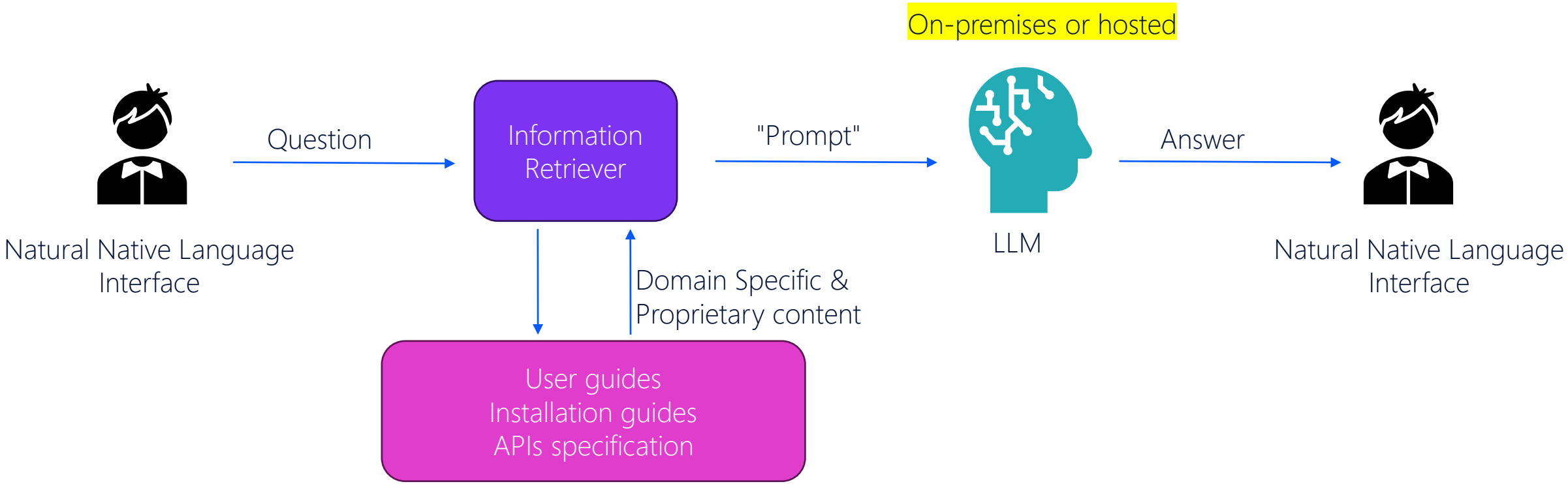




- Based on reference data or 5 sec telemetry from real subscribers
- Modeled via unsupervised learning techniques – no heuristics
- Provide realistic and unlimited data set to feed into simulations

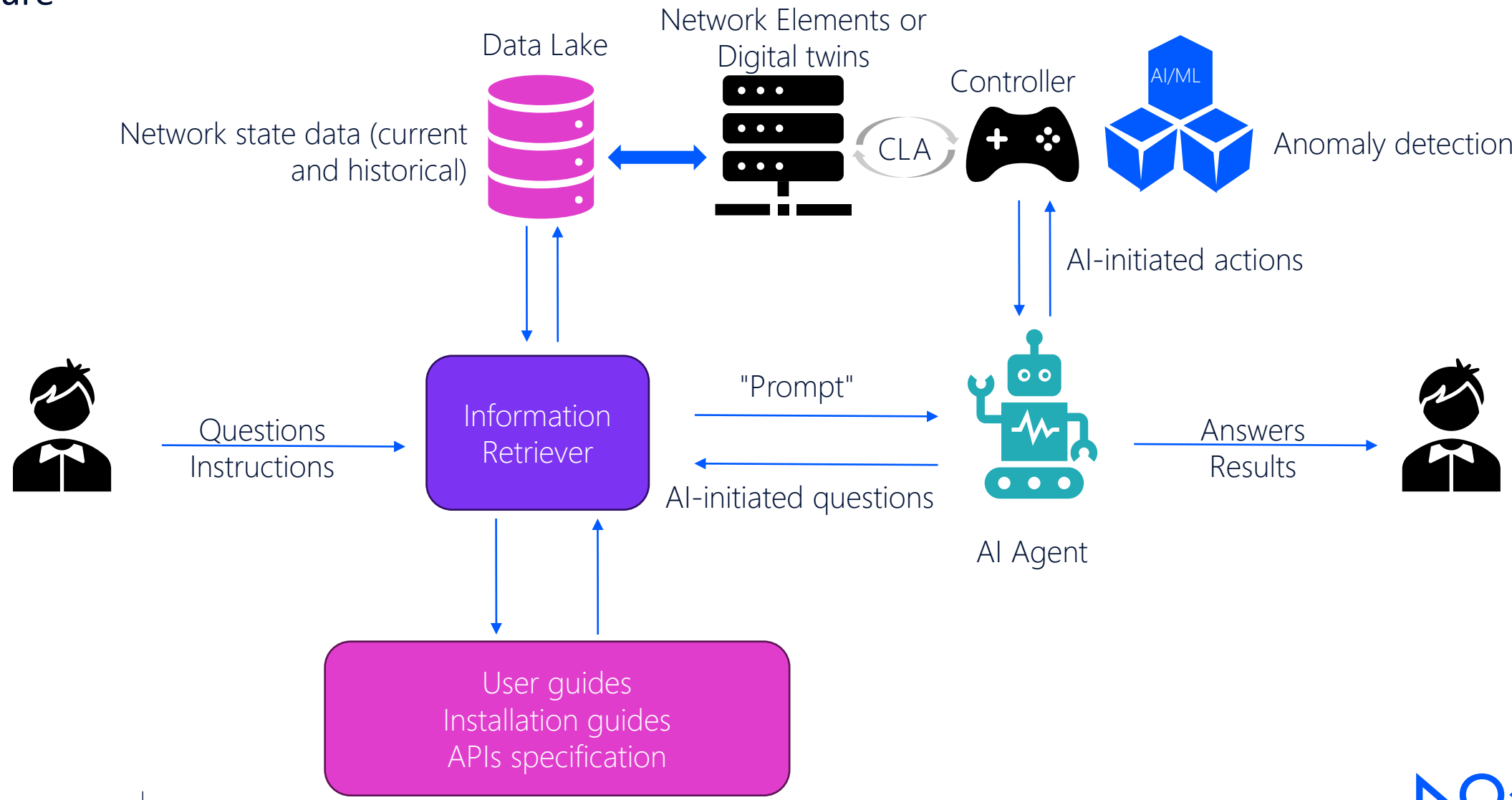
Large Language Models : Next generation of chatbot

Today : Proof of concept



AI Agent : Redefining the human-to-machine interface

Future




NOKIA

FUTUREWEI Technologies

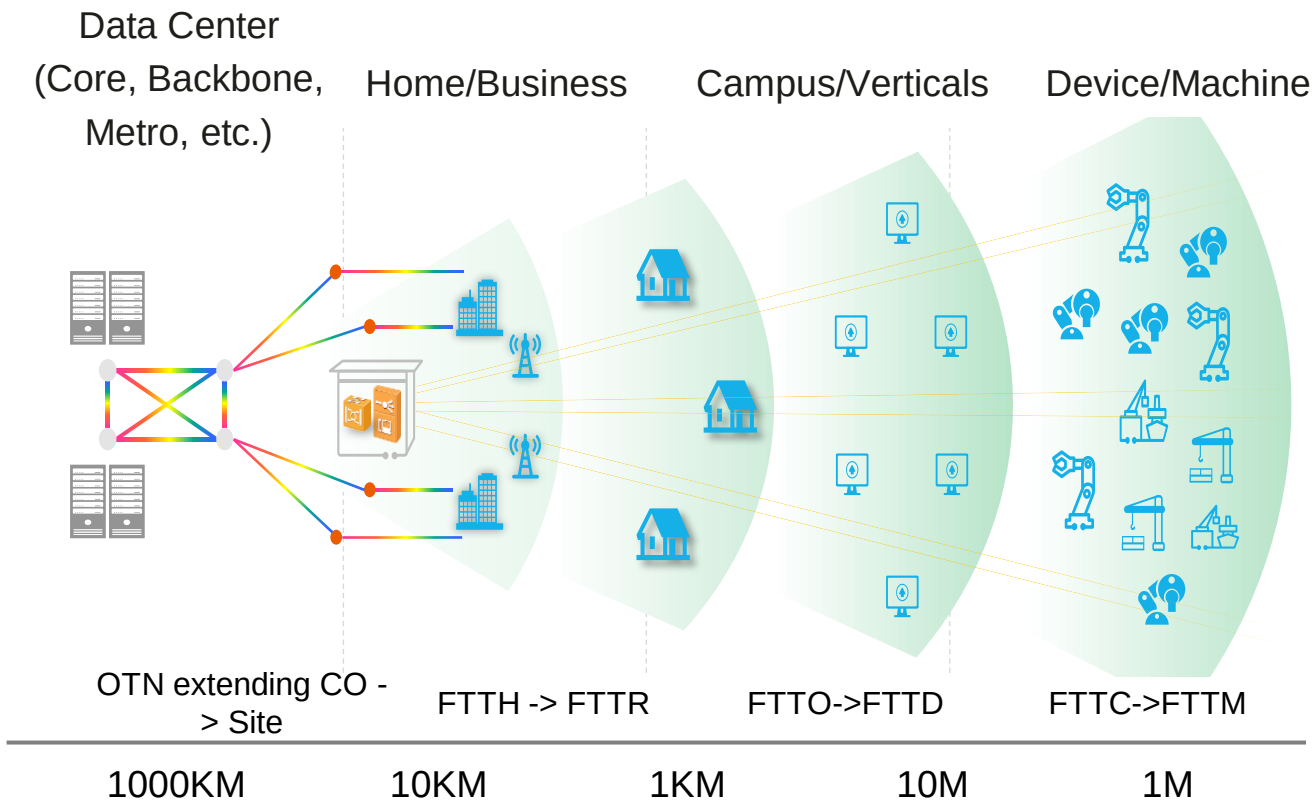
AI Applications and Impacts on Broadband Network

Aihua Guo, Principal Architect
BBF Town Hall Innovation Series
March 2024

Outline

- Broadband access network vision
- Challenges in broadband services
- Solution (autonomous network, digital platform, AI)
- AI applications
- Lab test

Broadband Network Infrastructure: Towards All-Fiber Network



- Broadened bandwidth spectrum for end users: fgOTN, 50G PON, WiFi7
- Premium services with guaranteed & reliable E2E QoS
- Autonomous Network
- Green networking

- Fiber to everywhere, end to end (FTTx, optical to cloud)
- Extending reach to more end users : 2Home/Room/Business/Consumer/Mobile/Device/Machine
- Massive number of connections: x3 (room), x10(desk), x30(machine), x100(smart city)

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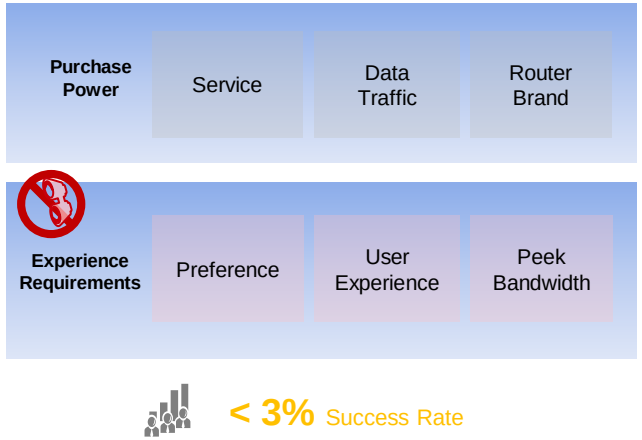
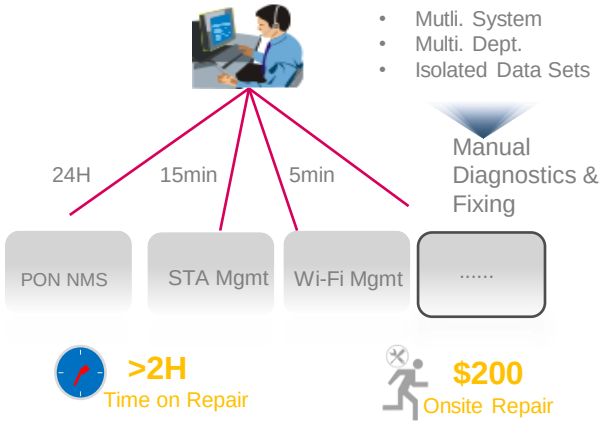
Broadband Service Challenges : Operation & Management

Low Marketing Success Rate



< 3% Success Rate

High O&M Cost



>2H Time on Repair

$200 Onsite Repair

Low Subscriber Loyalty

Un-visualizable user experience

90% quality incidents identified through user complaints

- High O&M cost with networks and subscribers growing significantly in size and complexity
- Exponential amount of data collected in the networks making it impractical with human-aided O&M

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Broadband Service Challenges : Paradigm Shift in User Applications and Requirements

Real-time User/Application Experience

WEB

HTTP videos

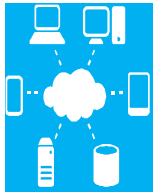
RTT<35ms

Real-time Calling / Live Streaming

RTT<11ms

Real-time AR/VR

Determined SLA



office

industry

Jitter < 10us

Availability > .999999

Home Scenario

Business Scenario

Scenario-based Self-Service Subscription

HSI

100Mbps

Giga-band

Scenario

- FTTR
- NGTV
- Smart Home
- …

Turn On in Days

Turn on in Seconds

Time-to-market Efficiency

- Scenario Analysis
- Service Design
- On-site Survey
- Installation
- On-site Service
- Turn-on & Testing

Months

One-stop service subscription

Flexible service orchestration

Automatic resource allocation

Hours/Minutes

Autonomy

Autonomous Network

Intelligence

AI, Big data & cloud

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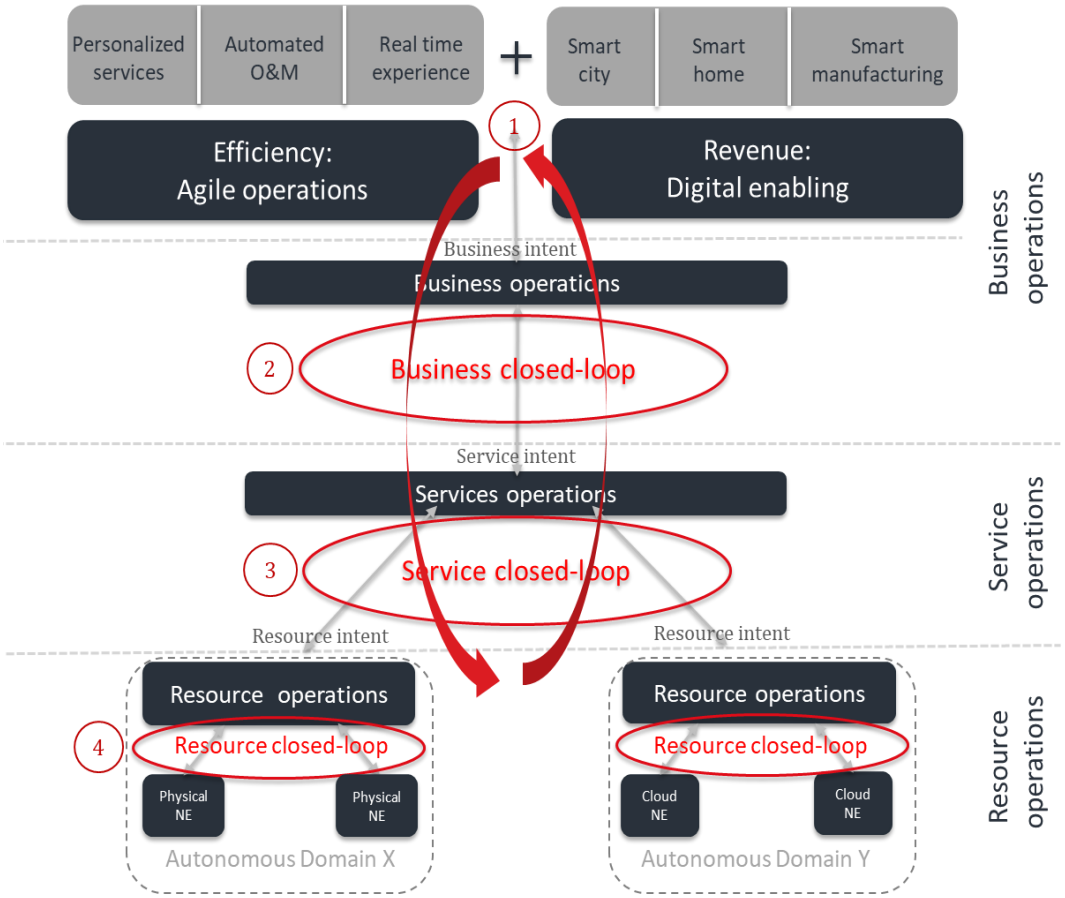
Building Autonomous Network for Broadband

Closed-loop Operation AI-embedded

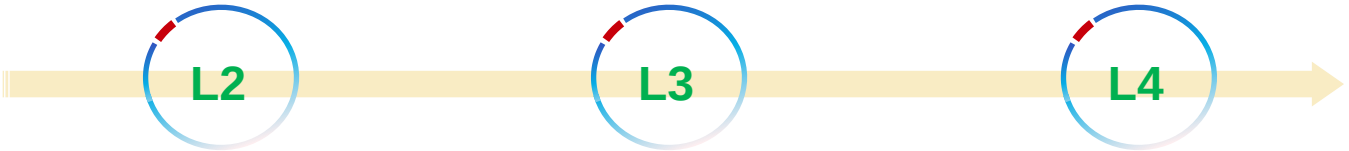


Generic Autonomous Network Level Classification Criteria

Autonomous Levels	L0: Manual Operation & Maintenance	L1: Assisted Operation & Maintenance	L2: Partial Autonomous Networks	L3: Conditional Autonomous Networks	L4: High Autonomous Networks	L5: Full Autonomous Networks
Execution	P	P/S	S	S	S	S
Awareness	P	P/S	P/S	S	S	S
Analysis	P	P	P/S	P/S	S	S
Decision	P	P	P	P/S	S	S
Intent/ Experience	P	P	P	P	P/S	S
Applicability	N/A	Select scenarios				All scenarios

P People (manual) S System (autonomous)

Industrial Consensus on Autonomous Network Evolution



-2021
Self-monitoring
Self-configuration

-2023
Self-analysis
Self-diagnosis

-2025
Self-optimization
Self-healing prediction and prevention

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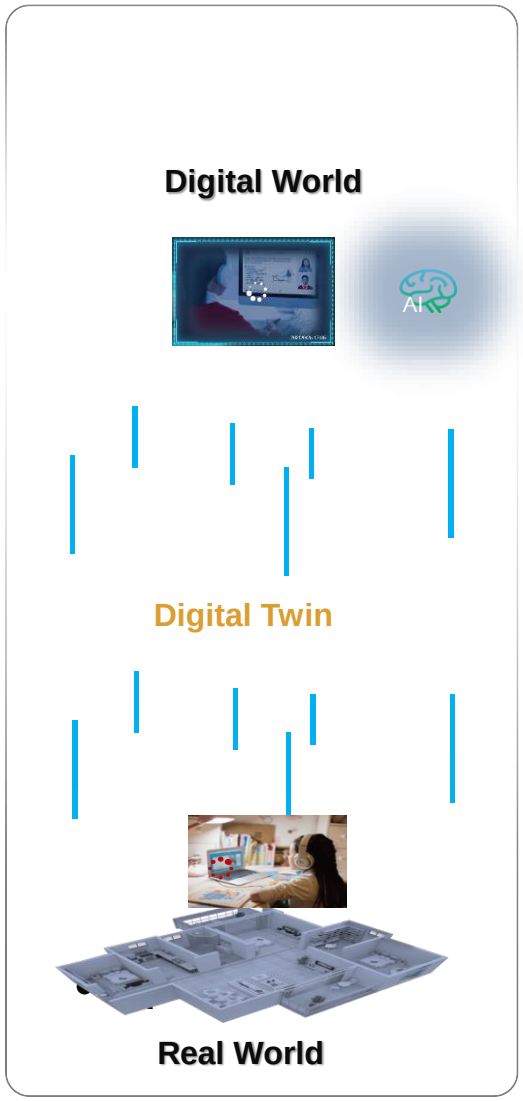
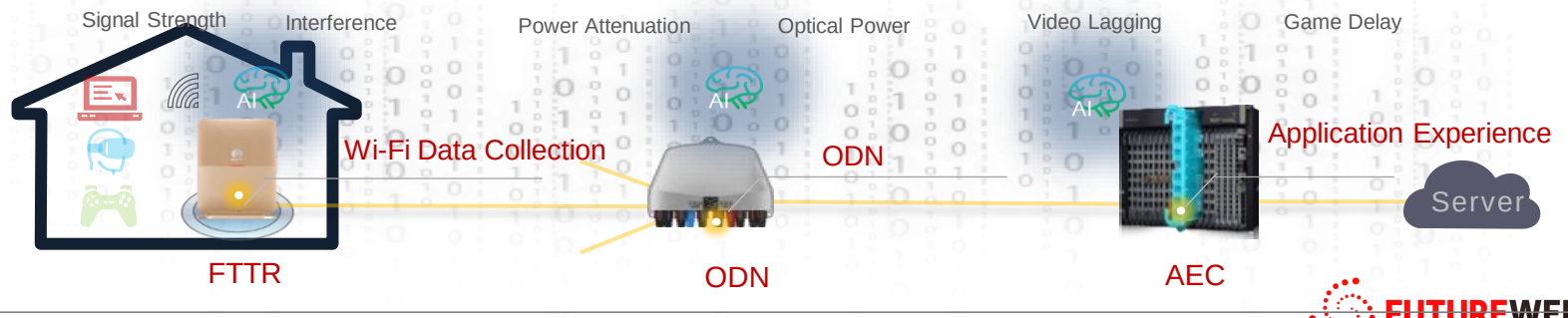
Cloud-Native Digitalized Foundation w/ AI for Autonomous Network



Application Identification | Efficient Deployment | Experience Perception and Improvement

5-dimension experience data modeling : network | terminal | service | user | application

	Lagging	Slow	Disconnected
Application			
User	Low QoS	High-BW usage	Low Satisfaction
Service	Delay	Jitter	Packet Loss
Network	Signal Strength	interference	Wi-Fi Rate
Terminal	Optical Power	Port Failure	Alarm/PM



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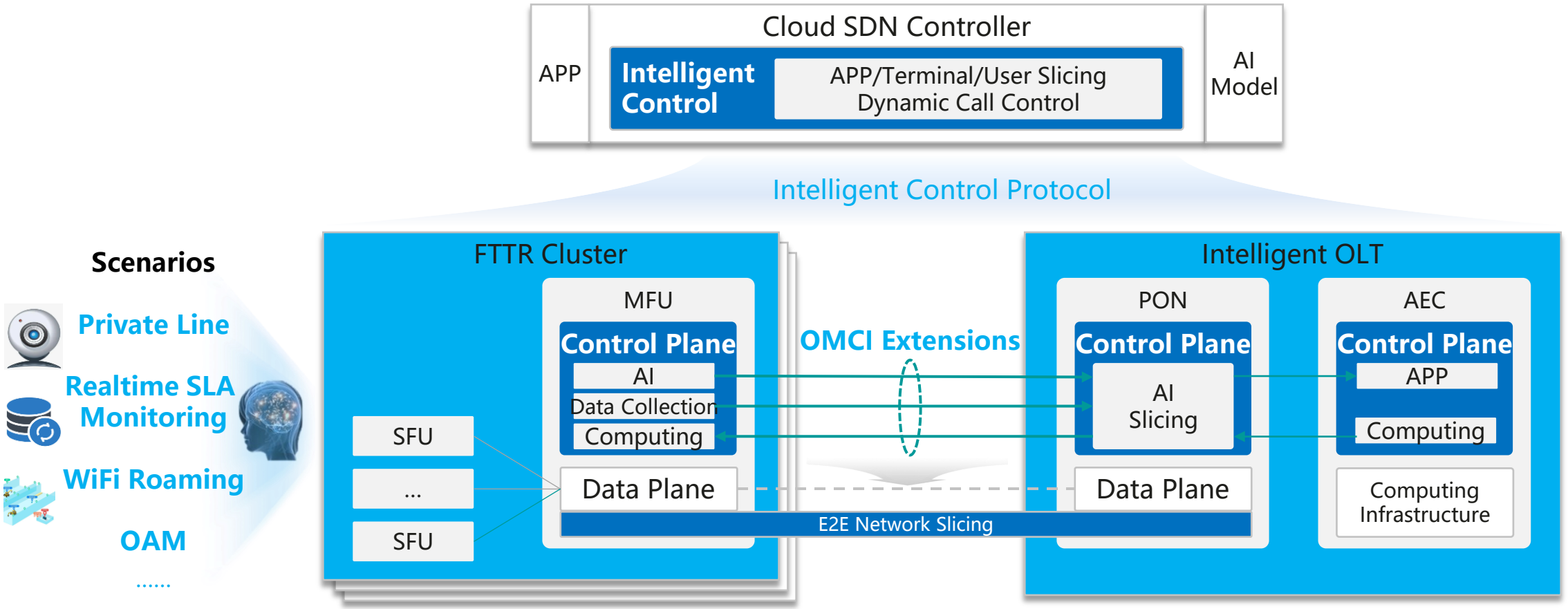
Cloud-Device AI Synergy



- ✓ Centralized SDN control and data analysis with AI/ML algorithms
- ✓ Distributed intelligence embedded on access nodes (OLT, ONT, etc.) to facilitate data collection and edge computing
- ✓ Requires intelligent coordination between the controller and devices

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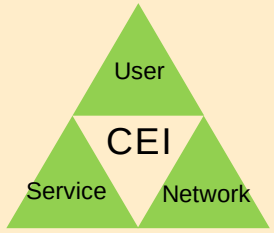
Measurable Real-time User Experience

Proactive Home Broadband Quality Evaluation

AI Model Training

Dimension



82 KPIs
PSPU Collection

256 KPIs
Parameter/Port

> 11,000,000
Model training

3-D Customer-Experience Index (CEI) model

Experience Analysis

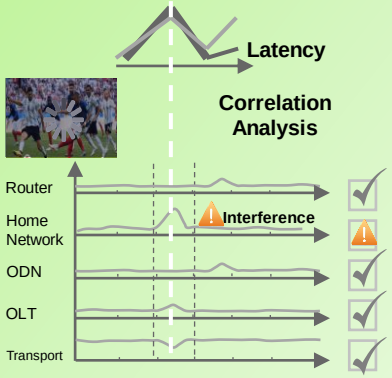
① Experience Score

② Regional Traffic Rank & Trend

Real-time Application Measurement

Precise Diagnostics

Streaming Lag



Intelligent Correlative Analysis of Application & Network KPI

- ❑ Precise marketing – categorize and identify customers with low-quality experience
- ❑ Instant troubleshooting to improve O&M efficiency and customer satisfaction
- ❑ Network and application performance optimization

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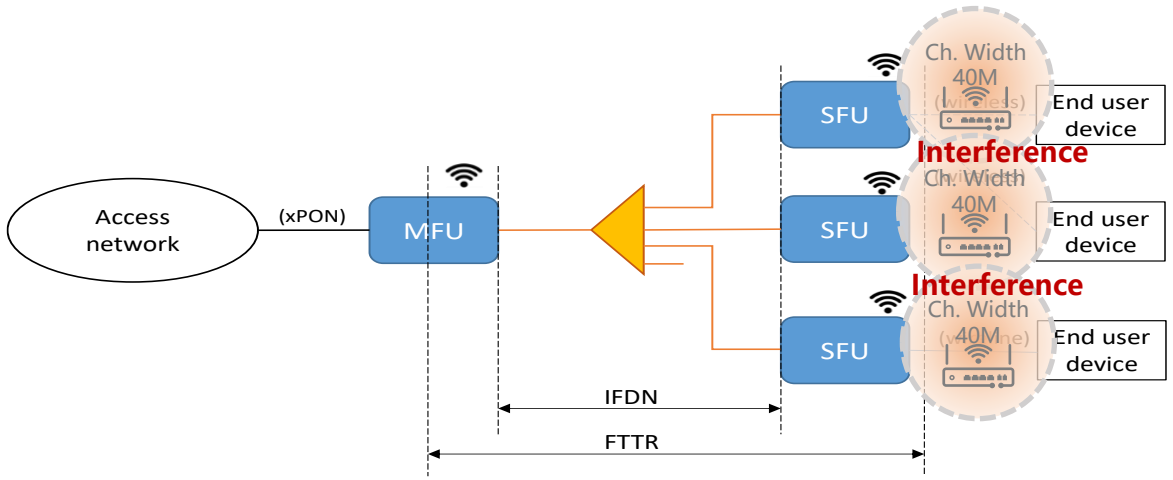
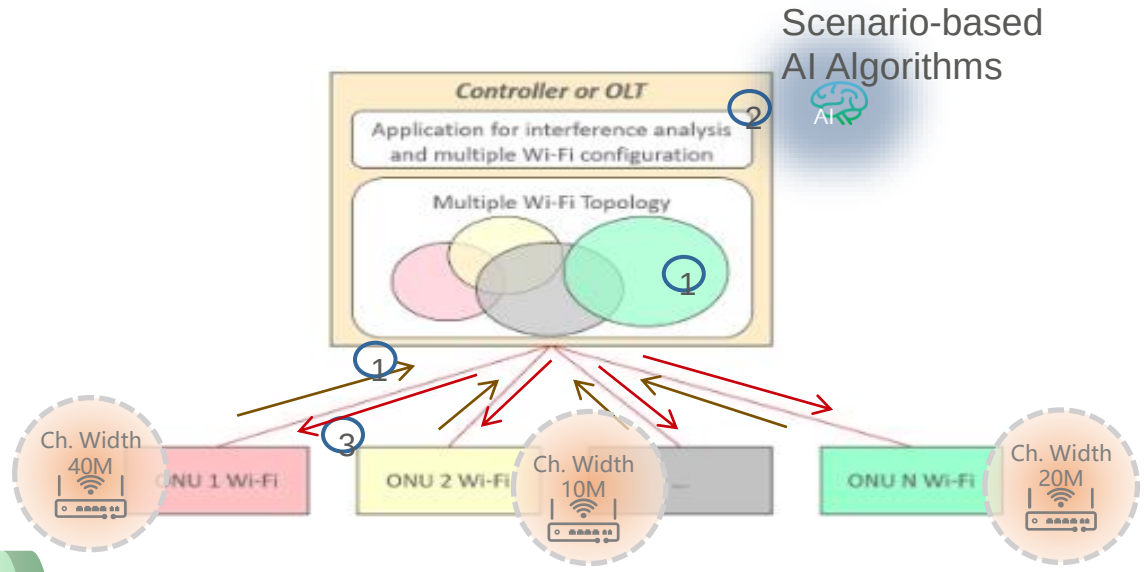
AI Application: Intelligent Wi-Fi Interference Control





- Dense ONU deployments with Wi-Fi APs a small area in FTTR scenarios can result in severe signal interference and degraded application experience
- # of users connecting to an ONU Wi-Fi AP can vary depending on the movement and bandwidth requirements of the users

1. Real-time status of all Wi-Fi devices are streamed to PON controller to build up Wi-Fi topologies
2. Scenario-based AI algorithms are used to analyze interference hotspots and create optimal Wi-Fi configurations
3. Optimal Wi-Fi configurations are pushed to the ONUs to take effect

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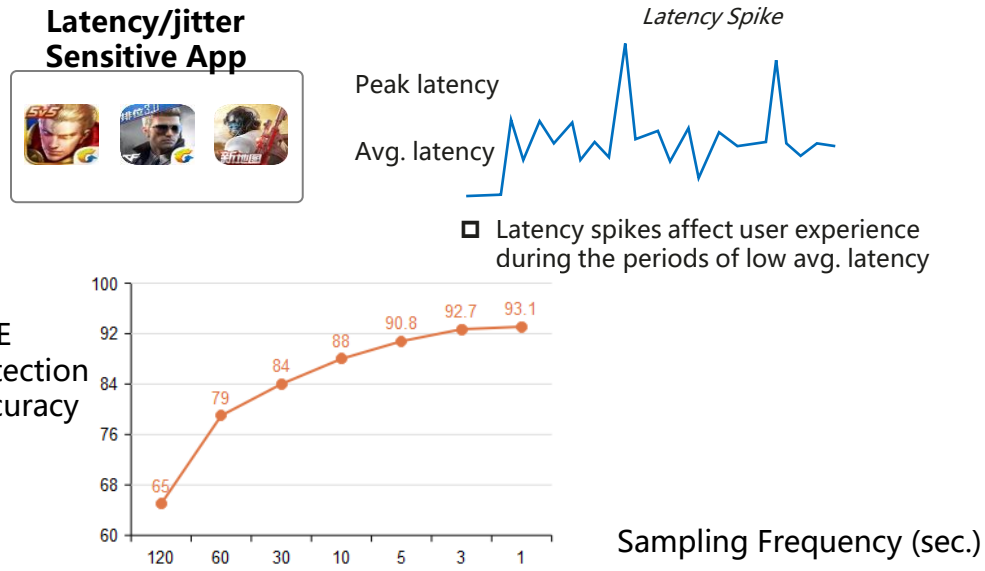
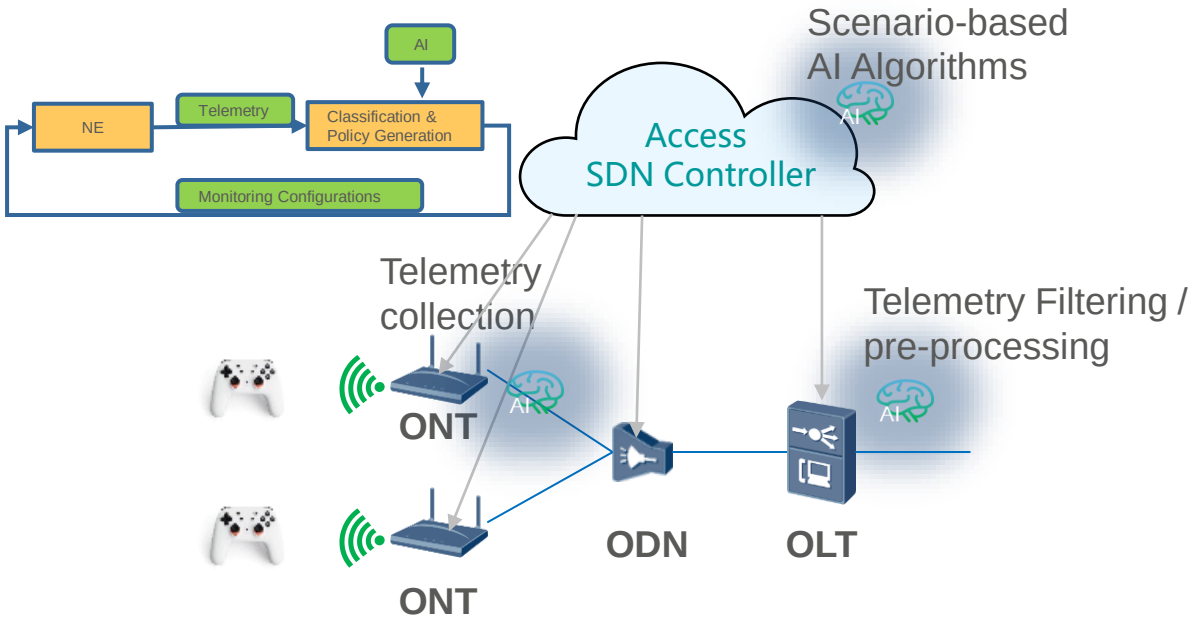
AI Application: Intelligent Performance Monitoring in Access & Home Networks

AIM Use Case #8





- User's QoE is impacted by the quality of Home & Access networks and is susceptible to dynamic traffic pattern changes over time
- Performance monitoring is essential to identify and resolve QoE problems. Frequent monitoring (collection with shorter interval) results in faster QoE problem detection at high cost.
- With closed-loop automation AI can help optimize the accuracy of QoE problem detection at a lower cost

- Dynamically adjust the monitoring frequency and amount of data collected over time
- Apply AI to analyze historical performance data to understand the life-cycle performance curve and identify potential risks/problems in advance
- Build profiles for key users (video, gaming, etc.) to apply fine-grained performance monitoring

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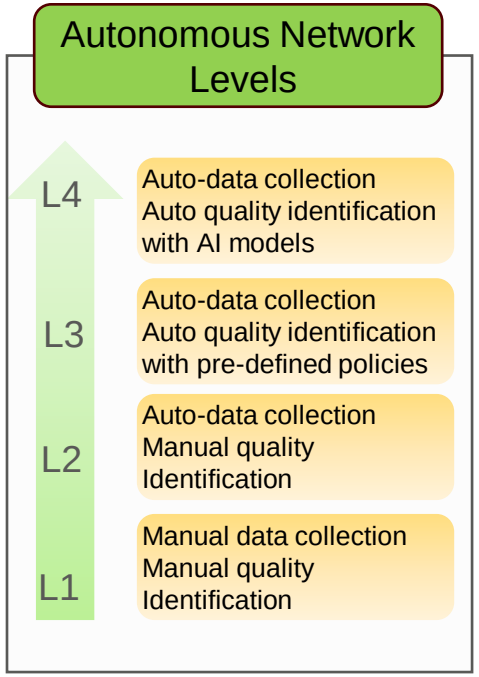
Lab Test : Autonomous Level Evaluation of Home Broadband Network

- Lab test was conducted by CCSA on a quality broadband intelligent operation and maintenance system
- +22 test cases focusing on user/application experience over a FTTR broadband access network
- Cloud-native access network controller with AI/ML analytics
- The result shows that in all tested use cases the intelligent solution achieved L3 - L4 autonomous network capability



Poor Quality Identification & Location	Scenario	Weak light recognition	Wi-Fi quality analysis	TCP flow quality		**Overall Score**
	• Weak light recognition • Wi-Fi quality analysis • TCP flow quality	**Collection & Identification - 4**	**Collection & Identification - 4**	**Collection & Identification - 4**		**3.5**
		Location - 4	**Location - 4**	**Location - 3**		
Poor Application Experience Identification & Location	Scenario	Remote office	Remote Education	Online Gaming	HD Video	
	• Remote office • Remote education • Online gaming • OTT Mobile Video • HD Video	**Collection & Identification - 3**	**Collection & Identification - 3**	**Collection & Identification - 3**	**Collection & Identification - 4**	
		Location - 3	**Location - 3**	**Location - 3**	**Location - 4**	
Management & Maintenance	Scenario	Poor quality user identification	Poor quality user optimization	Poor quality network optimization	Potential Customer	
	• Poor quality user identification • User optimization • Poor quality recommendation • Potential Customer	**Collection & Identification - 4**	**Poor quality user optimization - 4**	**Poor quality network optimization - 3**	**Potential Customer Tagging - 3**	
		Location - 4				

Summary

- The evolution in user applications and needs necessitates enhanced network automation and intelligence to adapt to the changing landscape
- Autonomous network empowered by AI/ML facilitates automated service operations and enhances the application/user experience while reducing O&M costs
- Reported test demonstrates real-world applications of AI for O&M automation, achieving L3-L4 autonomous networking

Thank You.

AI@EDGE

A SECURE AND REUSABLE ARTIFICIAL INTELLIGENCE PLATFORM FOR EDGE COMPUTING IN BEYOND 5G NETWORKS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101015922

5G PPP The 5G Infrastructure Public Private Partnership

Bringing the AI to the EDGE

The AI@EDGE Proposal and Challenges

Jovanka Adzic

TIM S.p.A. – Innovation

Lead Editor of AI@EDGE Overall Architecture

Neiva Linder, PhD

Research Leader – Network Management & Automation

Ericsson Research

AI@EDGE WP2 leader on Architecture

AI@EDGE

A **Secure and Reusable**

AI Platform

for **Edge Computing**

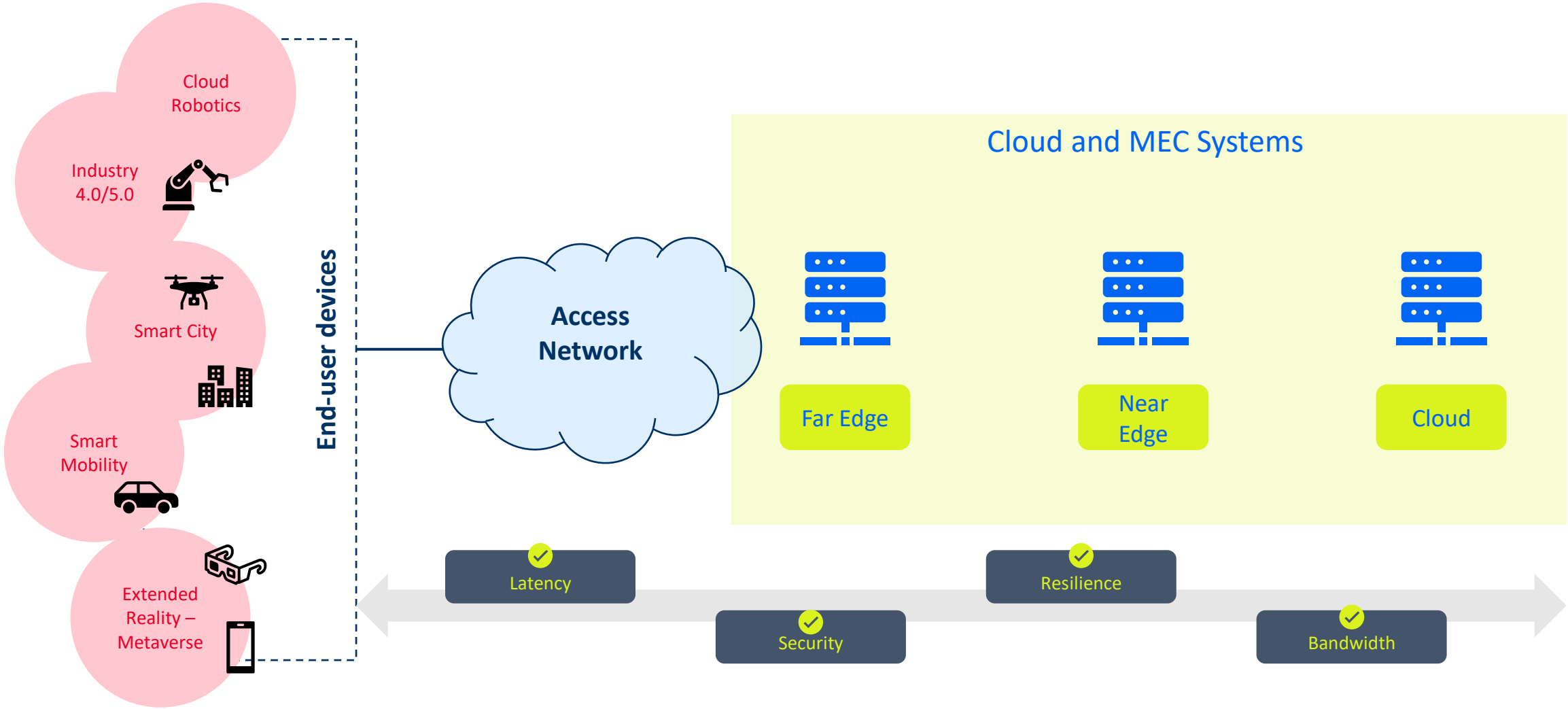
in **Beyond 5G Networks**

Key project figures

- H2020-ICT-52-2020 Project
  5G PPP – Smart Connectivity beyond 5G
- **Research and Innovation Action**
- Duration: 36 Months
  (1.1.2021-31.12.2023)
- 20 partners
  (10 Academia, 4 SMEs, 6 Industries)

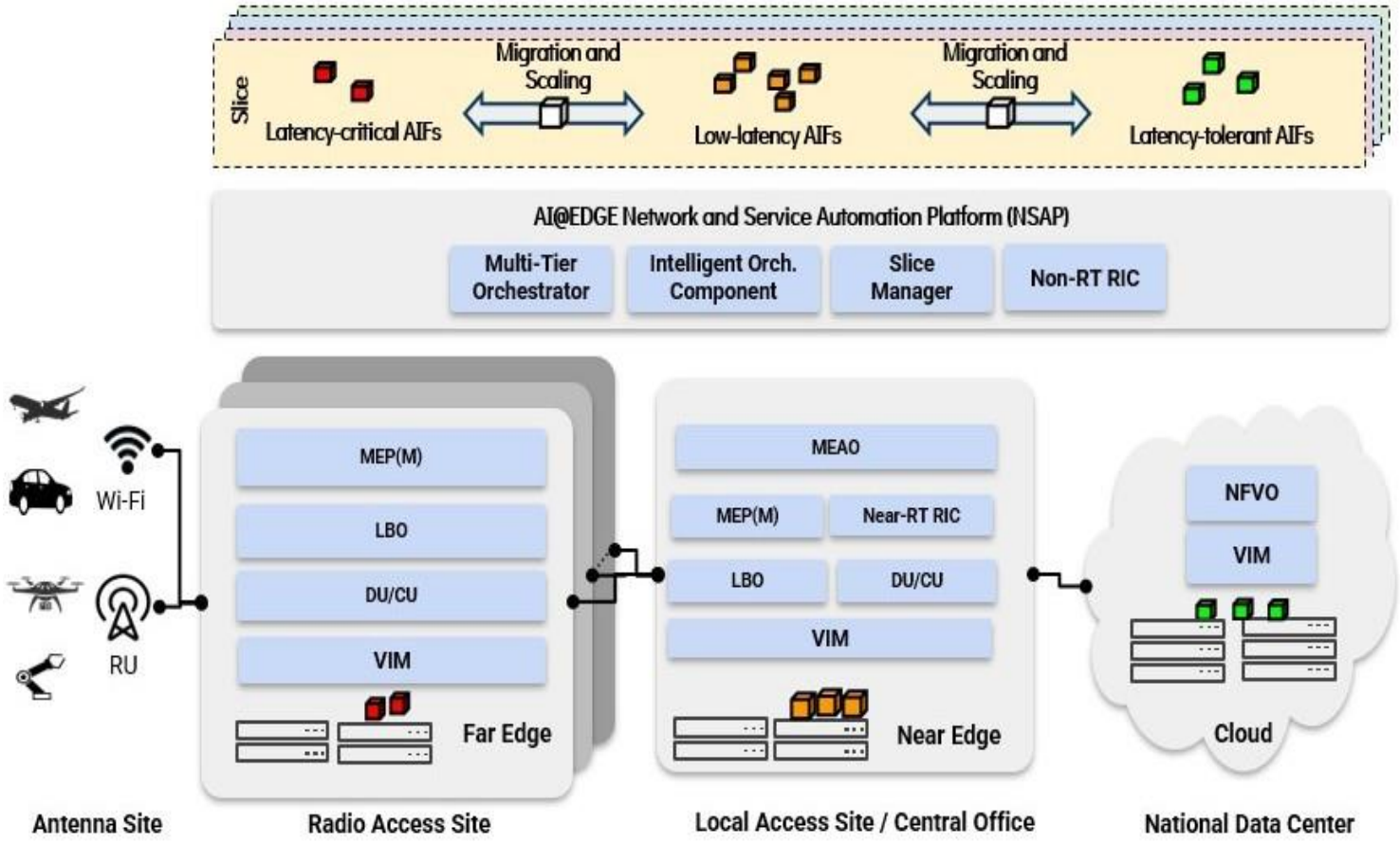
Bringing the intelligence to the Edge

Why?



AI@EDGE System Architecture

Position and Focus



Network and Service Automation

- AI/ML for closed loop automation
- Privacy preserving, machine learning for multi-stakeholder environments

Connect-Compute Platform

- Distributed and decentralized connect-compute platform
- Provisioning and Orchestration of AI-enabled applications
- Hardware-accelerated serverless platform for AI/ML
- Cross-layer, multi-connectivity, and disaggregated radio access

AI@EDGE Use Cases

Virtual validation of vehicle cooperative perception

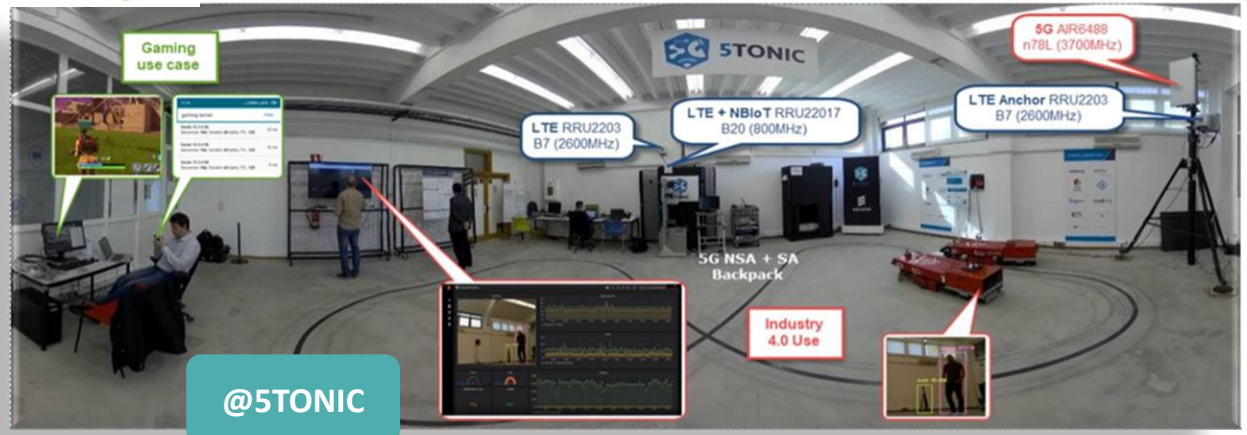
@POLIMI

@CRF

Secure and resilient orchestration of (I)IoT networks

@DFKI

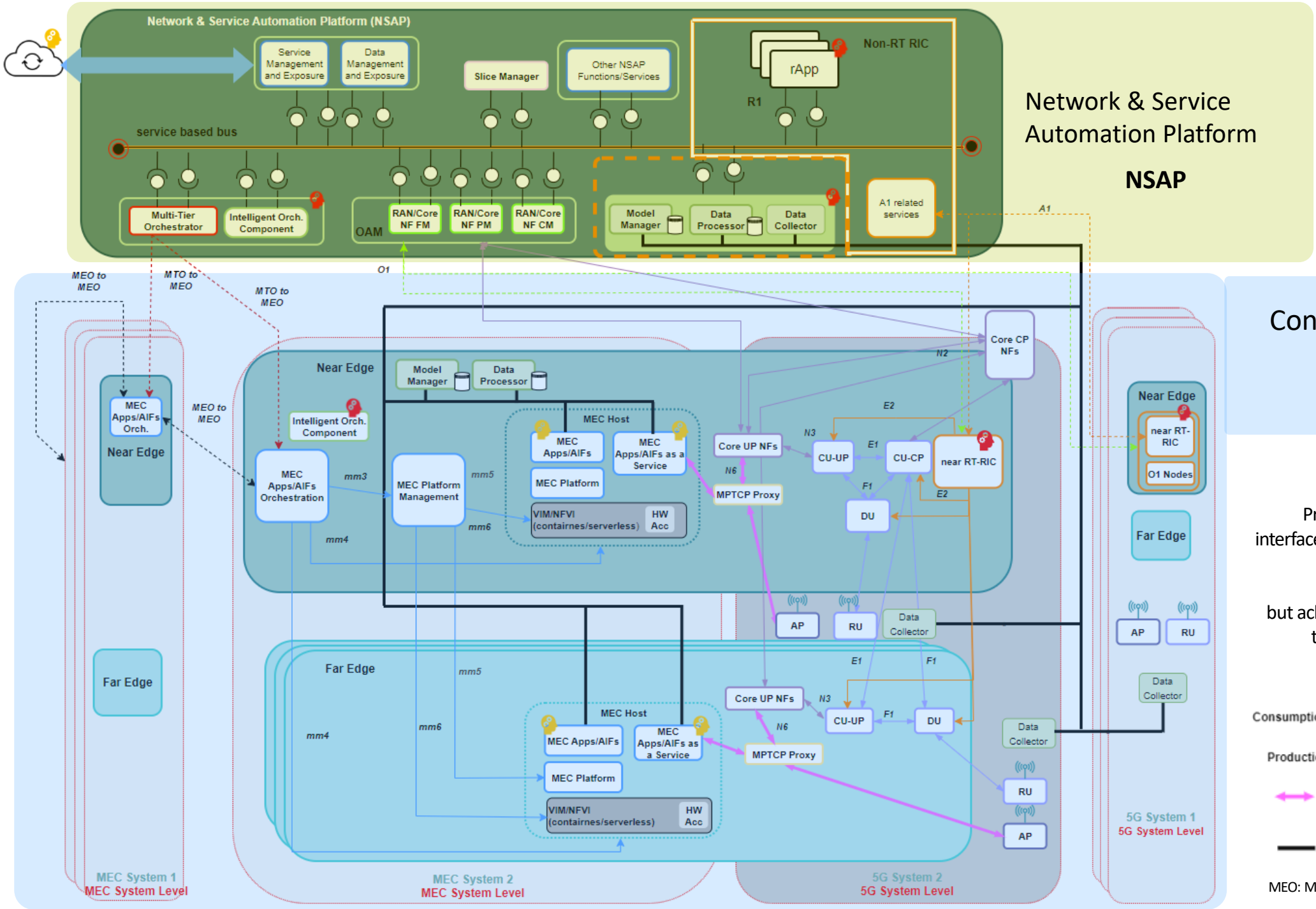
Edge AI assisted drones in beyond-visual-line-of-sight operations



@5TONIC

Smart content & data curation for in-flight entertainment and connectivity (IFEC) services

@SPI



Network & Service Automation Platform

NSAP

AI@EDGE

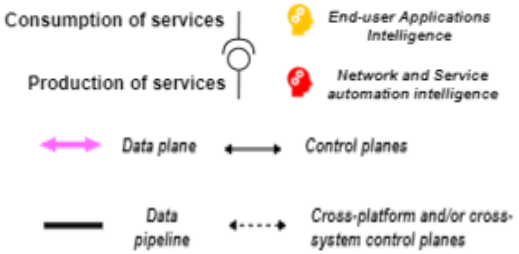
Deliverable D2.3

Connect & Compute Platform

CCP

AI@EDGE Architecture

Project focused on R&D of key interfaces/components only, such as **MTO, IOC, Model Manager, MTO <->IOC, MEO<->MEO** but acknowledging different technology trends, such as **SBA in NSAP**



MEO: Multi-access Edge Computing Orchestrator

AI@EDGE System Architecture

Key proposals: avoiding AI-Silos with reusable Data and ML pipelines

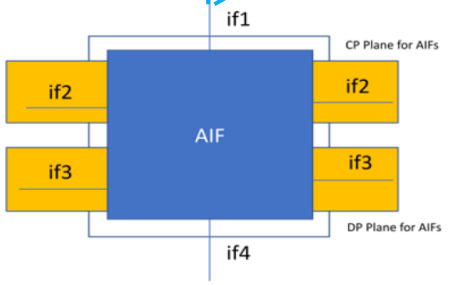
AI "In-platform" Inclusion

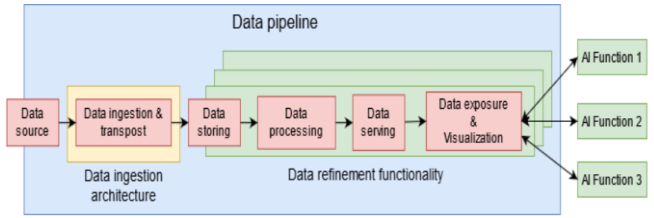
AI "On-platform" Inclusion

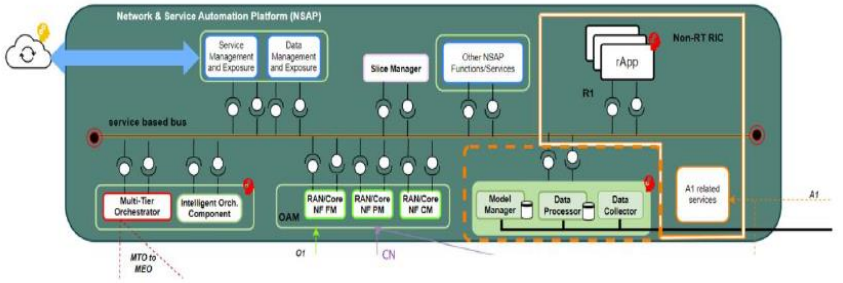
Data and ML Pipelines and Governance

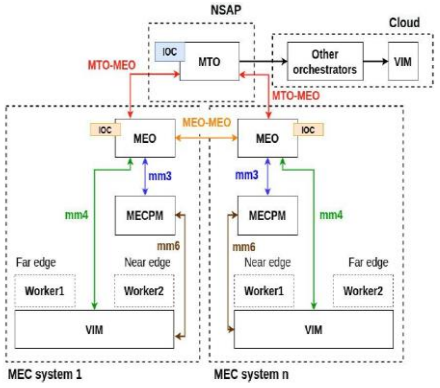
E2E System Orchestration and Management

Distributed Connect Compute Platform





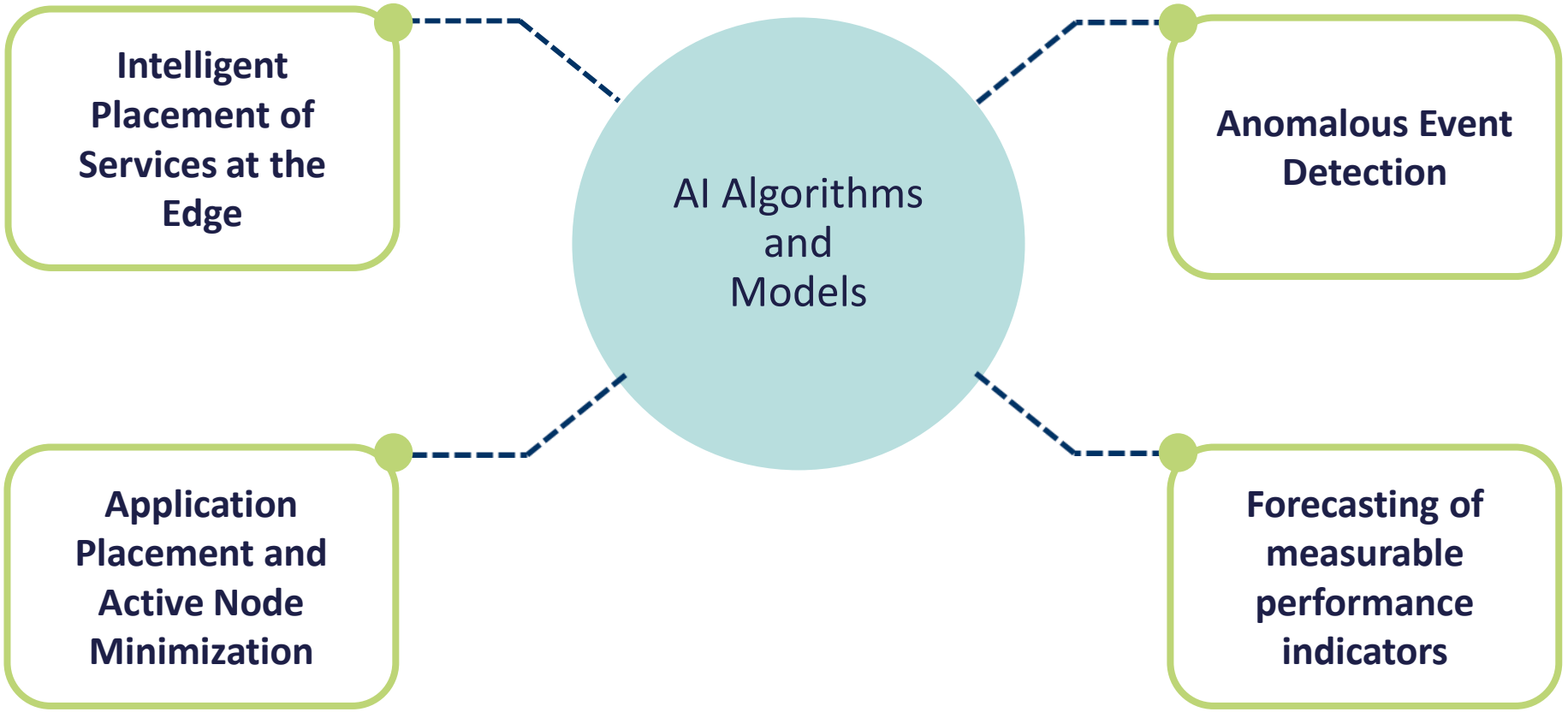




Going beyond specific Use Cases

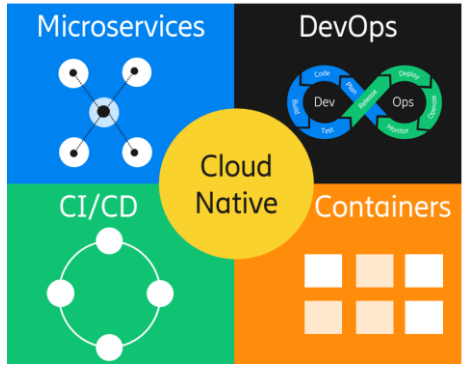
AI@EDGE System Architecture

“In-platform” AI: Rule-based AI, ML-AI, and combinations



Aspects of an AI-Native Architecture

Possible thinking, Cloud Native analogy



&

Intelligence everywhere

(→ MLOps)

Distributed Data Infrastructure

(→ DataOps)

AI Native Architecture

Exposure of AI services

(AIaaS)

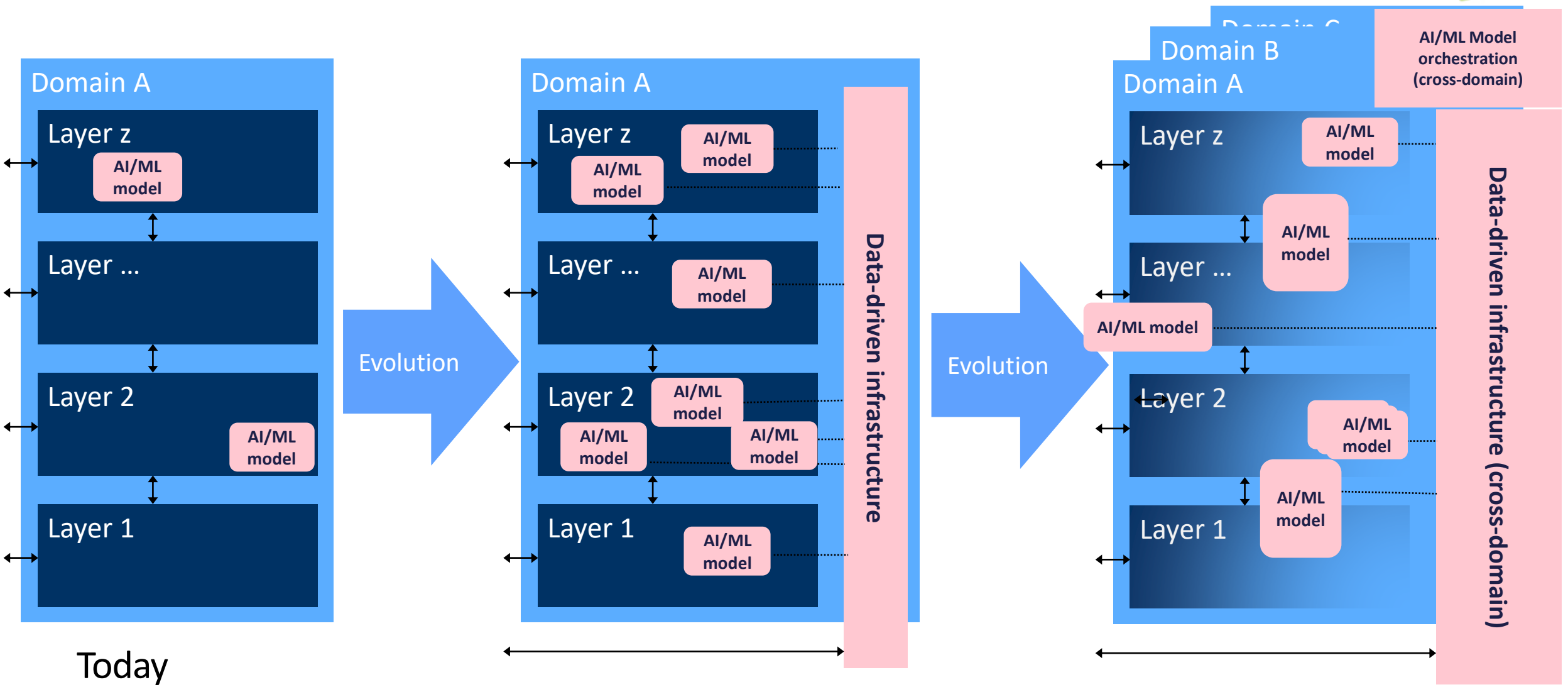
Managing all of this

(Zero-Touch Automation)

AI-Native Architecture = intelligence everywhere + distributed data infrastructure + zero-touch + (optionally) AIaaS

From using AI to AI-Native

Evolution



Challenges and Open Questions

Looking ahead

AI “in-platform” challenges

- There is a need to shift the focus towards edge DataOps and MLOps.
- Enhancing DataOps and MLOps to ensure deployment and management of machine learning models in federated edge environments.

- Energy performance included in overall indicators
- Further extend energy efficiency for 6G edge nodes.
- Further intersection and integration of device intelligence and edge intelligence

AI “on-platform” challenges

- Support ubiquitous data collection, aggregation, fusion, processing, and distribution services at the edge
- Enabling Cooperative Intelligence by running algorithms on platforms which may be geographically distant

Near real time Data Analytics processing

- Real-time requirements for AI/ML functions with constrained computation resources.

Software development for intelligent edge

Business dimension - Pricing and sharing mechanism

- An optimal resource allocation approach considering pricing and sharing mechanism
- Revenue distribution based on the executed workload need to be implemented to maintain fairness and incentivize collaboration

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Thank you

Any question?

Town Hall Innovation Series